The Book of Corn

A Complete Treatise Upon the Culture, Marketing and Uses of Maize in America and Elsewhere

For FARMERS, DEALERS, MANUFACTURERS *and* OTHERS—A COMPREHENSIVE MANUAL *Upon the* PRODUCTION, SALE, USE *and* COMMERCE *of the* WORLD'S GREATEST CROP

Prepared under the direction of HERBERT MYRICK, by the most capable specialists, including among others, A. D. SHAMEL, in charge of Corn Work, Illinois Experiment Station—H. J. WATERS, Director Missouri Experiment Station—E. B. VOORHEES, Director New Jersey Experiment Station—ALBERT W. FULTON, Managing Editor American Agriculturist Weeklies—J. C. ARTHUR, Purdue University, Indiana—WILLIS G. JOHNSON, late State Entomologist of Maryland, Associate Editor American Agriculturist—LEVI STOCKBRIDGE, ex-President Massachusetts Agricultural College—CLARENCE A. SHAMEL, Associate Editor Orange Judd Farmer—H. N. STARNES, Georgia Agricultural College—B. W. SNOW, Statistician Orange Judd Farmer—P. G. HOLDEN, Iowa Agricultural College.

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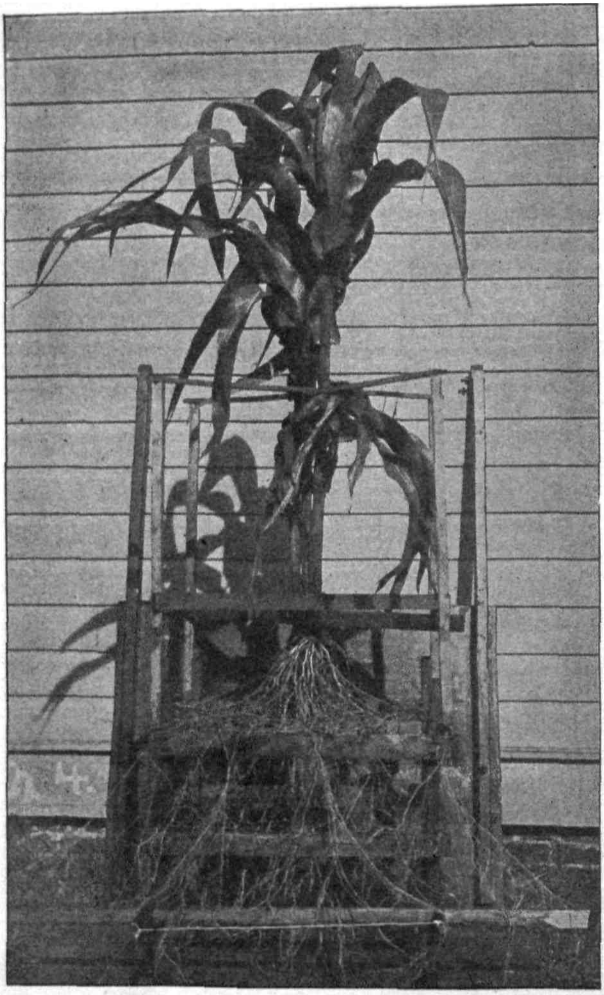

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INTRODUCTION

"MY chief regret in not visiting America is that I shall die without beholding what I conceive to be the most superb crop that grows, as it is, in itself, the most valuable," was the tribute to American maize, paid to the author by Sir John B. Lawes, the great Englishman, who did so much for scientific agriculture.

Impressed with this view of the corn plant, eminent specialists in the scientific and practical aspects of the maize industry have co-operated with singular enthusiasm in the preparation of the present work. The careful reader will marvel at the close co-operation of science with practice in the evolution of the corn plant and of the industries dependent upon it. There is no more fascinating or important chapter in American agriculture.

To the practical farmer, feeder or corn grower, much that the following pages contain must come as a revelation. The man whose knowledge of this subject is really comprehensive will be first to recognize the value and correctness of the mass of well-digested data herein set forth. And even the farmer who is wedded to the view that one hundred bushels of maize never have been and never can be grown on one acre, will perhaps obtain from this book a wider horizon and a larger inspiration as to the possibilities of corn culture.

When two hundred and fifty-five bushels of shelled corn, containing two hundred and thirty-five bushels of crib-cured or dry grain, are raised on one

acre—nearly ten times the average crop of the United States—the marvels of the corn plant must be recognized. When forty-five crops all over the country average ninety bushels of corn per acre, when improvement also in the chemical composition of the grain itself is demonstrated, and when the uses of the plant are becoming so manifold, it is full time to grasp what maize may mean to the world in general and to America in particular.

For the United States possesses practically a monopoly of the corn crop. Other countries produce from one-fifth to one-fourth of the world's supply, yet while this foreign production is capable of much expansion, the possibilities of corn culture in the United States are practically unlimited. This is in marked contrast to wheat, the production of which in Canada and Siberia, as well as in other regions, is destined to increase the already keen competition felt by American wheat in the world's market. It is evident, also, that new markets and new uses for the corn crop, both at home and abroad, are likely to keep pace with increased production. The larger exportation of corn from this country to Europe is but a foretaste of what is to come, while the possibilities of the Orient as a market for corn have hardly been touched upon. Of course this crop, both the corn and the fodder, should be very largely sold on the hoof or in the form of butter, milk or cheese, in order to maintain the highest agricultural prosperity.

The financial importance of corn to national prosperity is further emphasized by the fact that every cent that can be added to the price of a bushel of corn means an increased profit to the American farmer of twenty-five million dollars annually, a figure that will be doubled, when the United States produces five thousand

million bushels of corn in a single year, or twice the maximum grown up to this time. Such a doubling of the crop is by no means impossible, since yields of from fifty to one hundred bushels per acre, and even more, are becoming increasingly common. Moreover, corn readily adapts itself in various varieties to the soil and climate of all sections, it is easy of cultivation, and its value, both as a human food and a feed or forage for animals, encourages a wide growth. The superiority of the corn plant over other crops in these respects invites carelessness in its cultivation, and this accounts for the apparently low average yield per acre, which, however, is generous in comparison with the small grains.

Special emphasis should also be placed upon the corn plant as a renovating crop, whereas wheat and other small grains have relatively an exhaustive effect upon the soil. Unlike wheat, the production of which depends upon an ample supply of available nitrogen in or to the soil, maize possesses wonderful ability to gather in and assimilate nitrogen in many forms, as well as other elements of nutrition. To what degree the corn plant actually takes nitrogen from the air, either of the atmosphere or of the soil, experience shows that, if the land contains an abundance of phosphoric acid and potash, the more expensive nitrogen need not be largely applied in order to produce large and profitable crops of corn. Herein lies the explanation of the great yields produced under years of successive cropping in the American corn belt. This fact also demonstrates the fundamental value of corn in crop rotation, and its restorative effect upon the soil's fertility.

The various chapters which follow tell their own story, but a wealth of valuable data is also given in the Appendix—notably, the results in the now historic

corn contest conducted by *American Agriculturist.* The book is presented in the confidence that, in spite of its imperfections, it may prove effective in promoting that large improvement and vast development of the maize industry in America which is so confidently expected by the enthusiastic growers of *Zea Mays.*

HERBERT MYRICK.

The BOOK *of* CORN

CHAPTER I

Brief History of the Corn Plant

INDIAN corn is undoubtedly native to America, although for a long time some writers claimed it was of Asiatic origin. But as corn was not known in the old world until after it was found in the new, there can be hardly any doubt as to its original habitat. At present botanists almost unanimously concede that corn originated in America, and it is probable that it is indigenous to Mexico, although some of the South American table-lands present equally favorable conditions for the origination of a species of this character.

At the time of the discovery of the new continent corn was one of the staples of agriculture from the La Plata valley northward to the United States. It has names in all the languages. The natives planted it around their temporary dwellings where they did not form a fixed population. Indian corn was found as a common food when Europeans first landed in New York. Extensive fields of this grain were cultivated and the grain preserved for food. When Cartier visited Hochelaga, now called Montreal, in 1535, that town was situated in the midst of extensive cornfields.

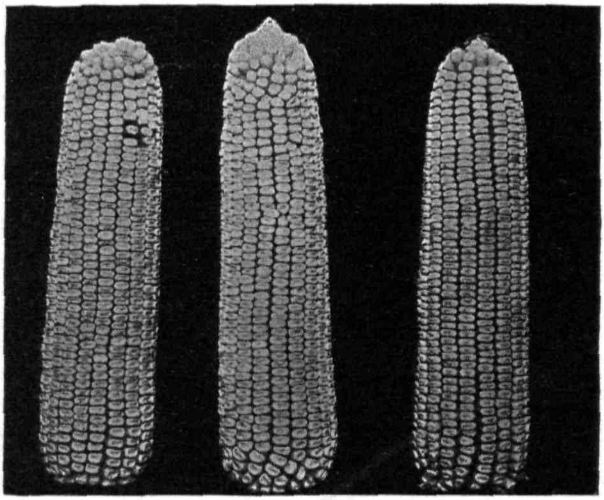
In 1620 the Pilgrims found quite extensive plantings near Plymouth, Massachusetts, and Columbus found it on the West India islands about the end of the fifteenth century. The burial mounds of the natives of North America who preceded those of our day, the tombs of the Incas, the catacombs of Peru, contain ears or grains of corn, just as the monuments of ancient Egypt contain grains of barley and wheat and millet seed. In Mexico, a goddess who bore a name derived from that of maize (Cinteotl) answered to the Ceres of the Greeks. At Cusco the virgins of the sun offered sacrifices of bread made from corn.

The Antiquity of Corn—Nothing is better calculated to show the antiquity and generality of the cultivation of a plant than this intimate connection with the religious rites of the ancient inhabitants. A most remarkable proof of the antiquity of corn has been discovered by Darwin. He found ears of Indian corn and eighteen species of shells of our epoch buried in the soil of the shore in Peru, now at least eighty-five feet above the level of the sea. The Smithsonian institution at Washington has an ear of corn found deposited in an earthen vessel eleven feet under ground, in a grave with a mummy near Ariquepe in Peru. The grains are rather sharp pointed, small, and slightly indented at the apex, lapping one over the other in thirteen rows.

Although nearly all parts of tropical and subtropical America have been explored by a great number of botanists, none has found corn in the condition of a wild plant, and the original form of the species is not identified as yet. Probably it may be a composite species of which no single form can be taken as the type. Some botanists consider that Indian corn originated from teosinte (*Euchlaena Mexicana*), an annual fodder grass, similar to corn in general appearance

and in the structure of the flowers, but differing in not forming an ear. This is extensively grown in Mexico and as experiments in crossing teosinte and corn have resulted in producing cornlike plants, the very close affinity of the two plants is clearly proven.

In summing up the conditions of Indian corn and its habitation in America before it was cultivated, the famous French botanist, A. de Candolle, says: "We



330 331 332

Fig 2—Uniform Ears of Boone County White

have nothing but conjectural knowledge. Maize is a plant singularly unprovided with means of dispersion and protection. The grains are hard to detach from the ear, which is itself enveloped. They have no tuft or wings to catch the wind, and when the ear is not gathered by man the grains fall still fixed in the receptacle, and then rodents and other animals must destroy

them in quantities, and all the more that they are not sufficiently hard to pass intact through the digestive organs. Probably so unprotected a species was becoming more and more rare in some limited regions, and was on the point of becoming extinct, when a wandering tribe of savages, having perceived its nutritious qualities, saved it from destruction by cultivating it. I am the more disposed to believe that its natural area was small, that the species is unique; that is to say, that it constitutes what is called a single-typed genus. The genera which contain few species, and especially the monotypes, have as a rule more restricted areas than others. Paleontology will perhaps one day show whether there ever existed in America several species of *Zea,* or similar gramineae, of which maize is the last survivor. Now, the genus *Zea* is not only a monotype, but stands almost alone in its family."

Whether the true origin of Indian corn, one of the most important cereals of the world, will ever be ascertained, is doubtful. But so much is certain, that the white settlers of America early learned from the native Indians the use of corn as an article of food. Several Indian names for certain preparations, such as samp, hominy, succotash, have passed into the language of the American people.

Since these early days, when cultivation was very crude, the grain has been improved so that it is now adapted to almost any climatic condition in the United States. The Indians planted their corn with sticks. Floods and drouths wrought havoc with the corn plants. Lack of cultivation and the constant struggle for existence prevented large development of the kernel. The early samples of corn were diminutive compared with those of to-day.

CHAPTER II

Botany and Varieties

INDIAN corn belongs to the gramineae or grass family. Botanically it is known as *Zea Mays.* This botanical name has a double meaning. *Zea* is probably derived from two Greek words meaning "I live" and "spelt," a grain with which the Greeks were familiar. The word maize is derived from the Haytian word "mahiz," which Columbus adopted when in Hayti. The word corn as commonly used the world over means any kind of grain used for food by man and animals. In the United States, it is applied to maize alone. When Europeans first landed in America and found this kind of corn they used the prefix Indian to distinguish it from the corn with which they were familiar in the old world. The corn plants vary greatly in hight, ranging from three to as high as sixteen or seventeen feet, but the standard hight is from five to eight feet. One main central stem bears the ears and long, broad, tapering leaves.

The plant is monoecious, that is, the male and female flowers are borne separately. The male flowers are borne on the tassels at the top of the stalk and produce the pollen. The pollen grains are produced about the time the silks, or female flowers, develop. The pollen is present in very great abundance, and it is estimated that each plant produces as many as eighteen million grains of pollen. The silks receive and retain pollen until the grains are fertilized. Originally, embryonic ears were probably produced at the juncture

of each leaf with the stalk. Selection and development has resulted in only one or two large and well-formed ears on each stalk. These ears bear developed kernels in from six to twenty-four rows.

The leaf is succulent and is divided into sheath and blade. The sheath surrounds the stalk, then the blade extends upward for some distance, and droops at the tip. The stalks have a hard shell or covering. The plant is semi-tropical, with very dark, green, luxuriant foliage. Wild corn must have seeds that can be readily disseminated, consequently the grains of the original corn were much smaller than those of the corn of to-day. Cultivated maize would soon disappear if the seeds were not preserved and planted each year. The grains of wild corn were large and wholesome enough to attract birds and wild beasts, which aided in the dissemination of the plant. In its original southern home some authorities believe Indian corn propagated itself by suckers grown from near the base.

The roots are of two classes. Those growing underground are fibrous and transmit plant food and water to the growing plant. The secondary roots arise from joints just above the ground and simply act as braces for the plant. These grow downward for some distance into the ground. The stem is divided into sections technically called internodes. These are furrowed on one side, the furrows alternating with each joint.

OUTLINE OF SPECIES GROUPS

While the genus *Zea* has but one species, there are almost innumerable forms and variations. The most extended study of these has been made by Dr E. L. Sturtevant, who has examined more than seven hundred and seventy varieties and synonyms, with a view of placing the nomenclature upon a sound scien-

tific basis. He has divided the polymorphic species (*Zea Mays*) into a number of groups which, on account of their well defined and persistent characters, may be considered as representing specific agricultural claims, and may properly receive specific nomenclature. The grouping that he has adopted is founded upon the internal structure of the kernel for our cultivated varieties and the presence of a husk to the kernel in the assumed aboriginal form. Arguments in favor of the specific claims for these groups are based primarily on the convenience thus attained, secondarily on the absence or rarity of intermediate or connecting forms, so far as our present data extend, and also on the antiquity of separation. Each race is characterized by numerous varieties, and these freely cross-fertilize. The relative differences between the races are clearly seen by splitting the kernels. These species groups as established by Dr Sturtevant are:

Zea tunicata, the pod corns. In this group each kernel is inclosed in a pod or husk, and the ear thus formed is inclosed in husks.

Zea everta, the pop corns. This species group is characterized by the excessive proportion of the corneous endosperm and the small size of the kernels and ear. The best varieties have a corneous endosperm throughout. This gives the property of popping.

Zea indurata, the flint corns. A species group readily recognized by the occurrence of a starchy endosperm inclosed in a corneous endosperm at the sides of the kernel, the starchy endosperm extending to the summit. By the drying and shrinkage of the starchy matter the summit of the kernel is drawn in or together and indented in various forms. In different varieties the corneous endosperm varies in length and thickness, thus determining the character of the indented surface.

Zea amylacea, the soft corns. This species group is at once recognized by the absence of corneous endosperm. Through the uniformity of the shrinkage in ripening there is usually no indentation, yet in some varieties an indentation may more or less frequently appear, but splitting the kernel infallibly determines this class. This group includes the Cuzco, the largest kerneled variety as yet known.

Zea saccharata, the sweet corns. A well defined species group characterized by the translucent, horny appearance of the kernels and their more or less crinkled, wrinkled, or shriveled condition.

Zea amylea-saccharata, the starchy-sweet corns. This species is founded upon the varieties found in the San Padro Indian collection of Dr Palmer. The external appearance of the kernel is that of a sweet, but examination shows that the lower half of the kernel is starchy, the upper half horny and translucent. These varieties have all a white cob, the kernels deeper than broad.

THE DEVELOPMENT OF DENT CORN

Zea Mays (Indian corn) is separated into six general groups,* representing different species. These groups are as follows:

I—*Zea tunicata,* the pod corns.
 Sub-group A, kernel broader than deep.
 Sub-group B, kernel as deep as broad.
 Sub-group C, kernel deeper than broad.

II—*Zea everta,* the pop corns.
 Sub-groups A, B and C as above.

III—*Zea indurata,* the flint corns.
 Sub-groups A, B and C as above.

*Bulletin No 57, Sturtevant, United States department of agriculture

IV—*Zea indentata,* the dent corns.
Sub-groups A, B and C as above.
V—*Zea amylacea,* the soft corns.
Sub-groups A, B and C as above.
VI—*Zea saccharata.*
Sub-groups A, B and C as above.

These divisions are the result of growing corn in different climates and for different purposes. The division which is of supreme importance commercially is the dent, *Zea indentata,* and its characteristics will be taken up in detail. The dent varieties have been developed in the central United States as a result of a corn which will give the largest yield of shelled grain adapted for general purposes. Naturally a corn of such general and wide importance has been the subject of great care in development. Unconsciously the corn growers of the past have selected a corn which would mature in the length of season natural to the climate in which it was grown. The character of a corn under such a system of selection slowly changed in response to the effect of climatic and soil conditions.

As a matter of fact, the history of the development of most of the strains of dent corn now grown is very brief. With few exceptions no record has been kept of the various crosses, and but few varieties have been selected toward a particular type for a special purpose for any considerable length of time. There have been but few systematic attempts at improvement, and the result is that as a rule mongrel or scrub varieties are grown. A few varieties, however, have been carefully selected in accordance with definite ideas as to improvement for about a quarter of a century, and have developed certain characteristics distinguishing them from other varieties. In such instances it has been found that if the corn has been selected toward a uniform type, the yield has been increased because of the pro-

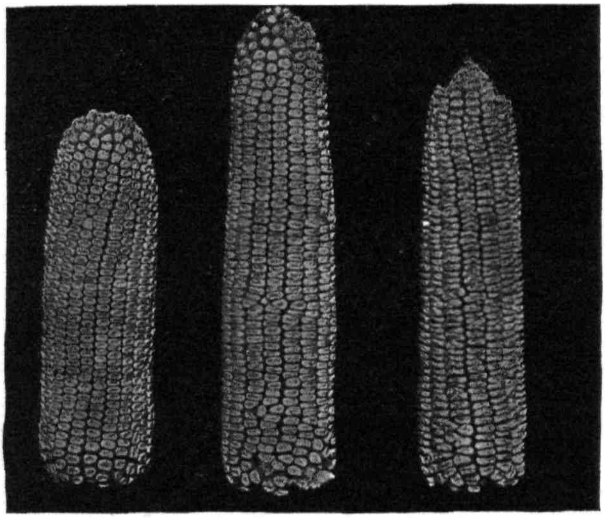
duction of uniformly better ears. The yields of varieties tested at the Illinois experiment station, 1888-1900 inclusive, show this result. Also, enough has been accomplished to prove that almost any characteristic desired in a variety can be fixed by persistent selection, and these characteristics can be continually improved by further selection.

The development of sugar in the sugar beet furnishes a splendid illustration of the possibilities of plant breeding. Starting with the ordinary beets with about four per cent of sugar, the French and German seed growers by selection have increased the sugar content to an average of twelve to sixteen per cent, making it possible to profitably manufacture sugar from this source. There are probably as great or greater possibilities in the corn plant, and these possibilities can be developed as easily as the sugar content of the beet. The development of the present breeds of cattle and other live stock plainly shows how careful, systematic and intelligent selection has improved these animals. The dairy and beef types have been developed from the same source; the light and draft horses, the bacon and lard hogs, etc.

Corn responds to selection as readily as do beets and cattle, and there is no longer any doubt that varieties of corn can be further improved by similar methods. The chemical composition of the corn kernel varies, and the experiments conducted by the Illinois station have conclusively shown that the proportion of the constituents can be varied at the will of the breeder. In other words, it is possible to increase or decrease the proportion of oil, or of starch, or of protein, by selection of the seed. When seed high in protein is planted a product high in protein is the result, and vice versa. The same thing holds true with seed high in starch or oil.

PHYSICAL CHARACTERISTICS

What is true of the chemical composition is eminently true of the physical characteristics of the ears or the stalks. For instance, the shape of the Leaming kernel has been changed by twenty-five years of selection, from the original shoe-peg type to a broader and deeper kernel with a deeper dent. Along with this



333 334 335

Fig 3—Uniform Sample of Boone County White

No 333, too short for circumference; 334, nearly correct length and circumference; 335, immature

variation in the shape of the kernel has gone an increase in length of ear and a slight increase in circumference. Again, in the case of the Boone County White variety the tips of the original corn were poorly

filled. This was due principally to the fact that the Boone County White ears are very long. As an ear matures from butt to tip, the tip maturing last, it frequently happened that the pollen was all gone before the tips of some of these ears had been fertilized. By selecting for seed only those ears which were well filled, in other words ears all parts of which matured in time for the pollen to fertilize them, the best samples of this variety have become well filled at the tips.

Effect of Selection—The Golden Eagle corn was originally a medium to shallow grained corn, but by constant selection toward deeper kernels and deeper dent, the variety has developed a very deep kernel with an unusually deep indentation. The amount of husks, length of shank, size of stalk, position of the ear on the stalk, the number of leaves, in fact every physical characteristic can be varied in a short time by simple selection. The present meager records give only an incomplete history of the development of the variations of corn varieties. It is just as important to know the character of every part of the corn plant as to know every characteristic of the animal. The size, shape and characteristics of the stalk strongly influence the development of the ear, and it is probable that it will be necessary to know the nature of the root development in order to breed intelligently.

VARIETIES OF DENT CORN

The varieties of corn described in succeeding pages are extensively grown in Illinois, Iowa, Missouri, Nebraska, Kansas, Indiana, Ohio and other corn growing states. These particular varieties have been grown for a long time by specialists who by selection of seed developed certain characteristics of ear and stalk. They possess certain characteristics of color, shape of kernel, shape and size of ear, etc, which have

been fixed by the breeder. Some possess characteristics that others do not have. From an examination of the different varieties, a list of the characteristics of corn, as shape of ear, cob and kernel, nature of indentation, color of grain and cob, character of tip and butt, number of rows of kernels on ear, length and circumference of ear, etc, has been made a basis of study of varieties. This list is given here that it may assist breeders to study their varieties of corn in a systematic manner. The corn grower can take an average sample of corn, and by going through the list of characteristics mark the ones possessed by his own variety. He can then take up the study of the characteristics in detail. Following is the list of characteristics:

Ear—

Cylindrical—Uniform in circumference from butt to tip.

Partly Cylindrical—Uniform in circumference for a portion of length.

Slowly Tapering—Taper slight, regular.

Distinctly Tapering—Taper very apparent.

Very Tapering—Extremely tapering.

Too Short for Circumference; Too Long for Circumference—Proper proportion of circumference to length is as three to four, or for medium varieties seven and one-half inches to ten inches.

Rows in Distinct Pairs—Alternate spaces between rows of kernels wider than the others.

Number of Rows—Counted three inches from butt.

Rows Lost—Disappearing after extending three inches or more from butt.

Narrow Space Between Rows—Rows pressed closely together.

Medium Space Between Rows—Distinct furrows.

Wide Space Between Rows—Wide furrows.

Circumference of Ear at Butt; Circumference of Ear at Tip—Measured two inches from the ends.

Length of Ear—Measured from butt to tip.

Rows Straight—Parallel with cob.

Rows Turned to Right; Rows Turned to Left—Rows angle to right or left of a straight line from butt to tip.

Butt—

Even—Entire end of cob exposed, with butt kernels at right angles to axis of cob.

Shallow Rounded—Cavity at butt shallow, broad.

Moderately Rounded—Cavity moderately deep, medium diameter.

Deeply Rounded—Cavity at butt deep, small diameter.

Compressed—Cob rounded at end.

Enlarged—Large butt with no extra rows of kernels.

Expanded—Large butt caused by extra rows of kernels.

Open—Greater space between rows at butt.

Depressed—Kernels at butt flat, smooth and short, indicating a tight husk.

Kernels Diverging—Space between summits of kernels in same row.

Tip—

Kernels in rows; rows may be traced to tip.

Flat—Cob flattened at tip.

Filled—Entire end of cob covered with kernels.

Capped—A central kernel projecting from filled tip.

Kernel—

Firm—Rigid on cob.

Loose—Movable on cob.

Roof-Shaped at One Edge—Convex at one edge and flat at the other.

Upright—At right angles with surface of cob.

Sloping—Leaning toward tip.

Overlapping at Summit—As shingles on a roof.

Straight Wedge-Shaped—Edges of kernels straight, tapering.

Rounded Wedge-Shaped—Edges rounded lengthwise, tapering.

Square at Top—Corners not rounded at summit.

Shoe-Peg Form—Long, narrow kernel holding size to tip.

Rounded Corners—Corners rounded at summit and base.

Rectangular—Short and broad, as broad at base as summit.

Beaked—With long, sharp tapering projection.

Slightly Rounded at Edges — Rounded lengthwise of kernel.

Small, Sharp Point at Summit—Pointed projection from chit side of kernel.

Round Smooth Dented—Round, smooth depression at summit of kernel.

Long Smooth Dented—Long, smooth depression.

Crease Dented—Edges of kernels pressed toward each other, leaving small space between, and edges parallel.

Pinched Dented—Edges of kernels pinched closely together.

Rough Projection Dented—With any rough, ragged or beaked projection from summit of kernel.

Bridge Dented—Crease dented with fold across center.
Crumple Dented—Seed coat wrinkled, as in sweet corn.
Breadth, Depth, Thickness—Exact measure.
Color—Note shade.

Shank—

Large—Nearly the diameter of cob.
Medium—Half the diameter of cob.
Small—One-third the diameter of cob or less.

Cob—

Large—Larger than four and one-half inches in circumference.

Medium—From three and one-half to four and one-half inches in circumference.

Small—Not more than three and one-half inches in circumference.

Color—Note shade.

REID'S YELLOW DENT

History—The following is the history of Reid's Yellow Dent as given by the originator and breeder, Mr James L. Reid of Tazewell county, Illinois: In 1846 Robert Reid brought from Brown county, Ohio, to Illinois a variety of corn called at that time the Gordon Hopkins corn. This was reddish colored, grown widely in the vicinity of the Red Oak settlement, the home of Mr Robert Reid. The corn was planted in Tazewell county, Illinois, by Robert Reid late in the spring of 1846, and a fair yield of immature corn was harvested. Seed was selected from this crop for the next year's planting, but on account of the immaturity of the seed a poor stand was the result. The field was replanted with seed of the Little Yellow corn, the missing hills being planted with a hoe. The corn has not been purposely mixed by Mr Reid since 1847, and has been improved by selection since that date.

It is adapted to central and northern sections of Illinois and similar latitudes. This variety is of medium early maturity, maturing in from one hundred to one hundred and ten days. The characteristics are very constant in all samples, due to the fact that they have

been strongly impressed by fifty years' selection. The photographs of the samples of Reid's Yellow Dent, one from the originator, Mr J. L. Reid, the other from Mr A. C. Rhoades, illustrate the uniformity of the characteristics running through the Reid variety. Mr Rhoades secured seed from Mr Reid about five years ago, and has grown this variety without intentional crossing since that time. In the samples of Mr Rhoades's corn sent to the Illinois experiment station

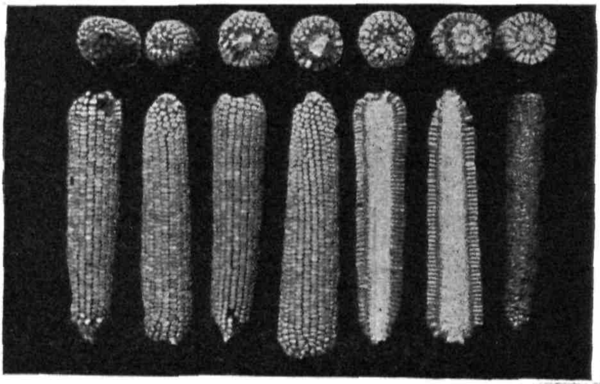


Fig 4—Reid's Yellow Dent

Butts, tips, size of cob, depth of kernel, and shape of ears

for examination, the indentation and shape of kernel, shape of ear, filling out at tips and butts, length and circumference, size and shape of cob, are uniformly and strongly Reid characteristics. This condition shows very decidedly that the characteristics that have been impressed on this variety of corn are strongly fixed and are uniformly reproduced. It offers one of the best illustrations of the effect of intelligent selection, the original corn with small ears, poorly filled

out, and small number of rows, being changed by selection to one of the most improved varieties of corn grown.

Characteristics—1, ear slowly tapering; 2, circumference 6.9 inches, length 9.5 inches; 3, kernels very firm on cob and upright; 4, number of rows 18 to 24; 5, space between rows very narrow; 6, kernels in distinct pairs of rows; 7, butt deeply rounded, very compressed, with diverging kernels; 8, kernels light yellow, square at top, tapering to a point by straight lines with long smooth to pinched indentation; 9, shank small; 10, cob medium, red.

GOLDEN EAGLE

History—The Golden Eagle variety was originated by Mr H. B. Perry of Stark county, Illinois, in 1871. Mr Perry selected seed from the so-called Mason County Yellow corn. This corn had rather small ears, red cobs and small kernels of a bright yellow color. The selection since that time has been toward a large proportion of corn to cob. This variety has been bred by Mr Perry on his farm without mixture since 1871 and has developed certain prominent characteristics, particularly deep grain and well-filled ends. The Golden Eagle is of medium maturity, usually maturing in from one hundred to one hundred and fifteen days; adapted to the central and south half of the northern division of Illinois. The characteristics are very uniform in samples grown under different conditions, a result of twenty-nine years of continuous breeding without crossing. The variety at present shows a great improvement over the original type and is one of the best examples of the results of selection.

Characteristics—1, ear slowly tapering; 2, circumference 7 inches, length 8.9 inches; 3, kernels loose

on cob and upright; 4, number of rows 16 to 20; 5, space between rows medium to wide; 6, kernels deep; 7, butt moderately rounded, compressed; 8, kernels deep yellow, very marked, rough projection at summit, straight edges and rough projection dented; 9, shank small; 10, cob small, red.

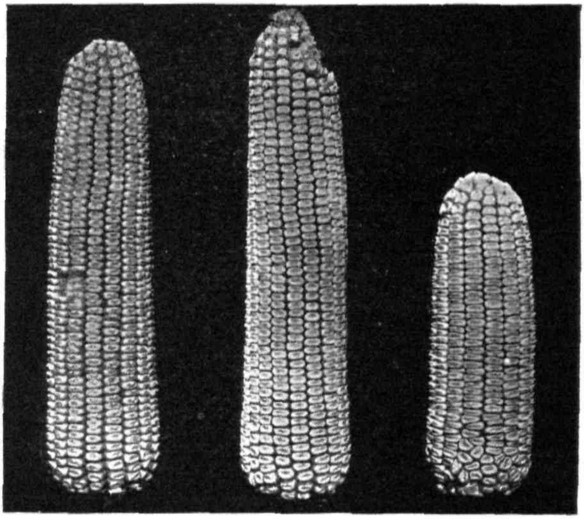
IOWA SILVER MINE

History—The Iowa Silver Mine variety of corn was originated by Mr J. H. Beagley of Ford county, Illinois, from seed selected from a prize-winning exhibit of white corn at Ford county farmers' institute in 1890. After sufficient corn had been grown to plant a twenty-acre field, the crop was sold to the Iowa seed company, which named it Iowa Silver Mine, and sold large quantities of seed to Illinois farmers. The originator has selected toward a creamy white color, cylindrical shape, tapering slightly at tip, with an average of about eighteen rows of kernels. This variety has been developed by selection, no crossing or mixing of varieties having occurred. The variety characteristics are strong, especially in those strains grown in the northern division of the state. The variety is from medium to early maturing, maturing in one hundred to one hundred and ten days, adapted to the north half of the central and the northern section of the state.

Characteristics—1, ears partly cylindrical and partly slowly tapering; 2, circumference 7.2 inches, length 8.7 inches; 3, kernels firm on cob and upright; 4, number of rows 16 to 20; 5, space between rows medium; 6, kernels in distinct pairs of rows, developing distinct rows at tips; 7, butt moderately rounded, compressed; 8, kernels cream white, deep, even at summit, except for rough projection, straight edges, tapering; 9, shank medium; 10, cob, small, white.

RILEY'S FAVORITE

History—The Riley's Favorite was originated by Mr James Riley of Boone county, Indiana, in 1885. It is a hybrid, the result of a cross of a large late corn, the Golden Yellow, with a small early corn, the Pride of the North. It has been bred in the following manner: A plot of one-half acre was selected away from



304 305 306

Fig 5—Length of Ear, Boone County White

No 304, proper length and size; 305, too long; 306, too short

any other variety of corn and planted in the usual way. As soon as the tassels began to appear, the barren and diseased stalks were all removed, leaving only healthy stalks. In this way future seed could not be fertilized from pollen from barren or dwarfed stalks. Mr Riley selected toward a medium-sized ear, small cob, well-

filled tips and butts, and stalks of medium hight. It is a medium to early maturing variety, ripening in ninety to one hundred and ten days.*

The Riley's Favorite variety is of early maturity, adapted to the central and northern divisions of Illinois. This variety strongly illustrates the fact that improvement takes place in corn breeding at present through selection without crossing of widely different varieties. Our varieties are sufficiently variable without introducing unknown characteristics, and selection will tend to develop these variations along the lines desired by the corn breeder.

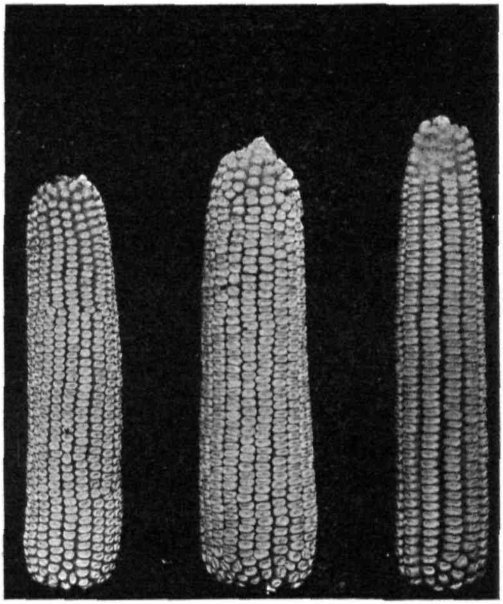
Characteristics—1, ear slowly tapering; 2, circumference 7.1 inches, length 9 inches; 3, kernels loose on cob and upright; 4, number of rows 16 to 20; 5, space between rows wide; 6, kernels in distinct pairs of rows, about half of the ears having distinct rows at tips; 7, butt moderately rounded, compressed; 8, kernels yellow, straight wedge-shape, pinched to rough projection dented, with a tendency in the rough summits to be beaked; 9, shank medium to small; 10, cob small, red.

WHITE SUPERIOR

History—The history of the White Superior variety as nearly as can be learned from the account of Mr

*As a matter of fact, neither Mr Riley nor other growers of Riley's Favorite have been able to fix the above characteristics of this variety. One season would develop a certain set of characteristics, while a different season would bring out different characteristics. This condition is a result of the cross made in the beginning of selection, in this way mingling together widely differing characteristics. In order to fix any characteristic, it takes years of selection for this point, and the Riley's Favorite has not been selected long enough to give the variety any fixed type. In the illustration of the samples of Riley's Favorite, one from Mr James Riley and the other from Mr T. A. Baldwin, little uniformity of characteristics of ear can be found. In a careful examination of these samples, it was clearly demonstrated that little similarity of characteristics existed between the two samples, although Mr Baldwin secured the seed of this variety directly from Mr James Riley only a few years ago. In a shipment from Mr Riley of about twenty-five bushels of Riley's Favorite seed in the ear, a large number of ears resembling the Pride of the North variety and about an equal number of ears similar to the Yellow Mastodon variety were found. A small proportion of ears of the Riley's Favorite type could be picked out by careful selection.

P. R. Sperry of Warren county, Illinois, a breeder of this corn, is as follows: Mr Shaffer, a seed corn specialist, brought from Pennsylvania to Warren county, Illinois, a variety of corn he called the White Elephant, about 1880. In 1895 Mr Sperry began se-



319 320 321

Fig. 6—Circumference of Ear, Boone County White

No. 319, well-proportioned, proper circumference; 320, too large for length; 321, too small for length

lecting seed from this variety for a different type than the White Elephant. He selected one bushel of seed of the type desired and planted this seed by itself, so that it would not be mixed with any other variety. In

changing the type of corn Mr Sperry changed the name to the White Superior. It is a medium to late maturing variety, ripening in one hundred and five to one hundred and twenty days.

His selection was as follows: Kernels one-half inch in length and one-fourth inch in width; ears eleven inches long, seven and one-half inches in circumference, with little space between rows. The White Superior is of medium maturity, and is adapted to the central and north central sections of the state.

Characteristics—1, ear slowly tapering; 2, circumference 7 inches, length 8.4 inches; 3, kernels firm on cob and upright; 4, number of rows 18 to 20; 5, space between rows medium; 6, kernels in distinct rows; 7, butt shallow, rounded, depressed, slightly compressed; 8, kernels white, tapering, with slightly curved edges and rough projection dented; 9, shank medium to large; 10, cob medium, white.

LEAMING

History—The Leaming variety was originated by Mr J. S. Leaming of Hamilton county, Ohio, in 1826. Mr Leaming began selecting seed at this time from the ordinary yellow corn grown on the Little Miami bottoms, Hamilton county, Ohio. He selected this seed toward a standard type in his mind for fifty-six years, to be followed by his son, J. S. Leaming, Jr. His method of selection was to go through a field as soon as the earliest husks began to show signs of ripening, selecting ears from stalks tapering from butt to tassel, ears well filled over points, straight rows of kernels, and ripening in from ninety to one hundred and ten days.

The Leaming strain as grown by Mr E. E. Chester of Illinois is from seed secured from Mr J. S. Leaming in 1885. Mr Chester has selected corn for

seed from those ears showing the first ripening of the husk so as to secure corn maturing in from one hundred to one hundred and twenty days. No crossing has been allowed, the corn being planted in large isolated fields. Mr James Riley of Indiana secured seed of the Leaming variety from Mr Chester. Mr Riley selected for a thick, strong stalk, ears close to the ground, medium cob, deep grain and bright yellow

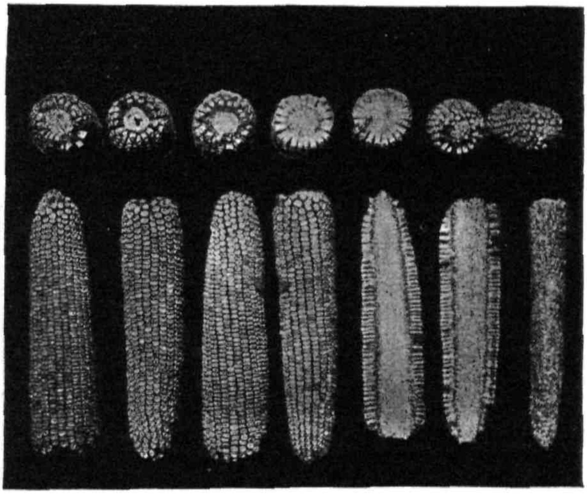


Fig 7—Leaming

Butts, tips, size of cob, depth of kernel and shape of ears

kernels. Mr J. H. Coolidge of Illinois secured Leaming seed from Mr Chester. Mr Coolidge has selected for a deep grain, long ear, well filled tip and butt, uniform rows of kernels and early maturity.

The Leaming variety has the most uniform characteristics of any variety of yellow corn grown. Its adaptation to widely different conditions of soil and

climate by selection has done much to strengthen these characteristics. It is no doubt the type from which many varieties of yellow corn have been developed, as most of the yellow varieties show some of the characteristics of the Leaming corn; and when their history is traced back they are usually found to have been developed from the Leaming seed. The Leaming variety is of medium maturity, adapted to the central division of Illinois. The three-quarters of a century of breeding has fixed the following characteristics, and they can be found strongly developed in strains bred by different corn breeders, modified by the breeder in his selection of seed. See Fig 7.

Characteristics—1, ear tapering; 2, circumference 7 inches, length 9.3 inches; 3, kernels firm on cob and mostly upright; 4, number of rows 16 to 24, with a tendency to drop rows about the middle of ear; 5, space between rows medium; 6, kernels in distinct pairs of rows, mixed at tip; 7, butt moderately rounded, slightly compressed, with tendency to expand; 8, kernels yellow, wedge-shape, with square-cut summits and nearly straight edges, long dimpled to pinched dented; 9, shank medium to large; 10, cob medium, red.

BOONE COUNTY WHITE

History—The Boone County White corn was originated by Mr James Riley of Boone county, Indiana. Mr Riley began selection from a large, coarse variety of corn grown in Boone county, commonly known as the White Mastodon, in 1876. This White Mastodon seed secured by Mr Riley was planted in a separate field from other varieties, and has never been crossed, being changed in type by selection. Mr Riley attempted to remove the barren stalks by cutting out such stalks before they produced pollen. After several

years of selection he gave his new type of corn a new name, Boone County White.

Seed of the Boone County White was early secured by Mr O. C. Block of Champaign county, Illinois, and by careful selection for about ten years the characteristics of shape of ear, kernel and cob, and the indentation of the kernel have been changed. The proportion of circumference to length has been increased by Mr Block. The indentation of kernel in the Block

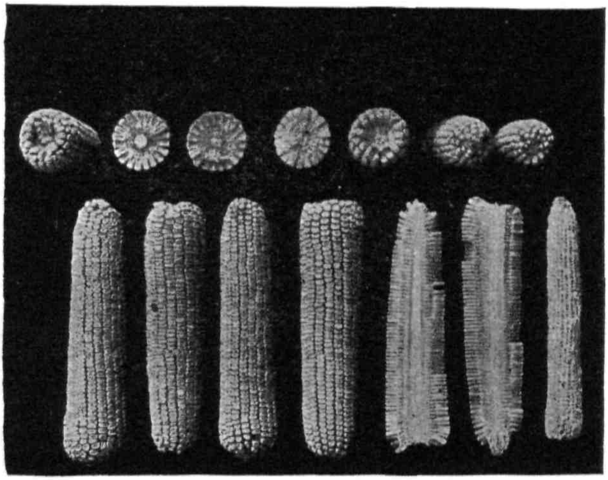


Fig 8—Boone County White
Butts, tips, size of cob, depth of kernel and shape of ears

type is deeper than the Riley type, but the shape of kernel has not been greatly changed. No doubt that by continued selection along the lines already laid down by Mr Block and other growers of the Boone County White, a distinct type can be produced.

The Boone County White is of medium to late maturity, ripening in one hundred and ten to one hun-

dred and twenty days, adapted to central and southern sections of Illinois. It has been bred for large ears, and consequently matures slowly. There is a tendency to the production of a poorly filled tip on account of the length of ear, which must be overcome by careful selection.

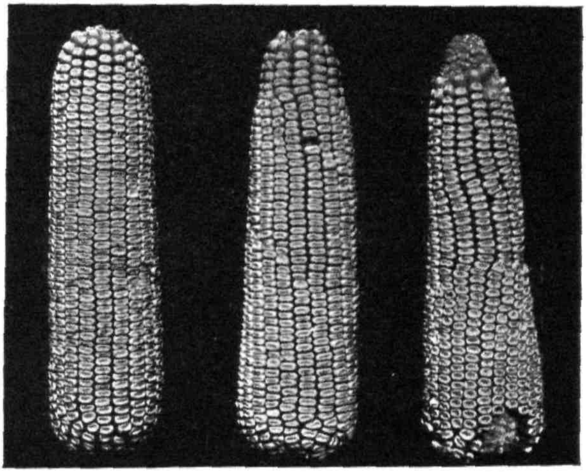
Characteristics—1, ear slowly tapering; 2, circumference 7.5 inches, length 9.3 inches; 3, kernels firm on cob and upright; 4, number of rows 16 to 22; 5, space between rows medium to wide; 6, kernels in distinct pairs of rows, developing distinct rows at tip; 7, butt moderately rounded, slightly compressed, enlarged or expanded; 8, kernels white, broad, even at summit, with slightly curved edges and creased to rough projection indentation; 9, shank medium; 10, cob medium to large, white. See Fig 8.

These varieties of dent corn above described will be added to in the future in a systematic way. Already organizations have been formed in Illinois and Iowa for the purpose of assisting corn breeders in the development of varieties. These seed corn breeders' associations have established corn registers for the purpose of recording authoritative pedigrees of varieties of corn.

VARIETIES OF FLINT CORN

The second division of corn, the flint corns, are a product of eastern and northern United States. Here the cold climate induces a heavy protecting seed coat to be formed over the outside of the kernel early in the season. This does not allow of the development of a deep kernel. Usually the kernels are broad and shallow, the ears having not more than eight to fourteen rows of kernels. The kernels are composed of an unusually large proportion of starch, and this kind of corn is used in large quantities for starch manufactur-

ing purposes and for hominy. Owing to the shallow kernels this corn matures in a short time, usually from eighty to ninety-five days. The proportion of leaves is comparatively small, and the plants are not so large or high as the plants of the dent corn. This is partly due to the fact that the dent corns are usually grown in soils very rich in nitrogen, which induces a heavy development of stalks and foliage. The flint corns grown



301 302 303

Fig 9—Shape of Ears, Boone County White

No 301, cylindrical, proper shape; 302, partly cylindrical; 303, very tapering

in the clay soils do not have such a large amount of nitrogen to draw upon and the plants are consequently not developed to such a great extent as the dent types.

VARIETIES IN NEW ENGLAND AND NEW YORK

While very little direct effort has been made to produce distinct varieties of corn in New England,

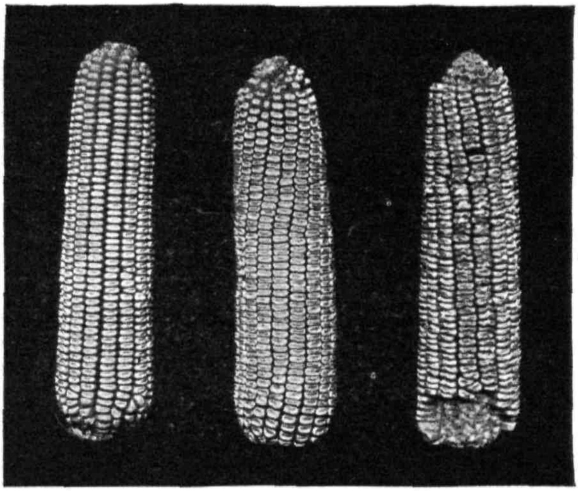
there are many kinds with such distinguishing characteristics as to entitle them to a place among the varieties. A few comparatively new varieties, such as Longfellow and Angel of Midnight, have been introduced and have gained some general standing, but the most popular kinds have only a local reputation and are rarely known outside of a few townships.

In many cases in New England, New York, and perhaps Pennsylvania, well-fixed types have been established by growing one kind of corn for a long period of years on the same farm without any change of seed. These varieties are frequently designated by the name of the family by whom they have been grown, as "Doolittle" corn and "Warren" field corn. Not infrequently some particular kind of corn has been grown on the same farm for several generations of a family, without new seed being introduced. At least two instances are known in Connecticut where one kind of corn has been grown on a certain farm by the same family for over one hundred years. By growing any plant for a long period of years under uniform conditions of soil and culture, and by the exercise of considerable care in selecting the seed, well-fixed types will be developed.

The season is so short in New England that mostly flint varieties are grown. In preparing statistics for a large number of Connecticut varieties of corn for the world's fair of 1893, it was found that the growing season of flint varieties ranged from ninety-six to one hundred and twenty-five days, while for a smaller number of dent varieties it ranged from one hundred and fifteen to one hundred and sixty-seven days, the greater number requiring a season of over one hundred and thirty days. The average growing season in Connecticut without damaging frosts is about one hundred and forty-five days, yet there have been

several seasons within the past fifteen years when the growing period covered only one hundred and thirty to one hundred and thirty-five days. From these facts it will be seen that only a comparatively few varieties of dent corn are adapted to New England conditions.

Eastern Corn Varies Greatly in Composition—Analyses of a large number of varieties grown in the



324 325 326

Fig 10—Kernel Indentation, Boone County White

No 324, smooth grains; 325, medium rough; 326, rough grains

east show a wide variation in the composition of corn. For example, out of ninety varieties analyzed by the Connecticut experiment station, the highest percentage of protein in the dry substance of the grain of any variety was 14.53 per cent, while the variety showing the lowest proportion contained 8.33 per cent. It has been found, too, that the percentage of protein varies

somewhat with the season, being lower in a wet season than in a dry, due probably to the removal of nitrogen from the soil by the leaching action of heavy rains.

There is probably no doubt that those varieties high in protein can be maintained high in protein by thorough culture and the proper selection of seed. By planting seed from varieties high in protein the protein content of the resulting crop will be correspondingly high. Fertilizers rich in protein will also do much to maintain and even to increase the protein content of corn. In experiments made by the Storrs (Connecticut) experiment station, the average percentage of protein in the grain grown on plots where liberal amounts of nitrogen were used as fertilizer was about one per cent above that in the grain grown where only mineral fertilizers were used. In the stover a relatively greater increase was obtained where the nitrogen was used, than in the seed.

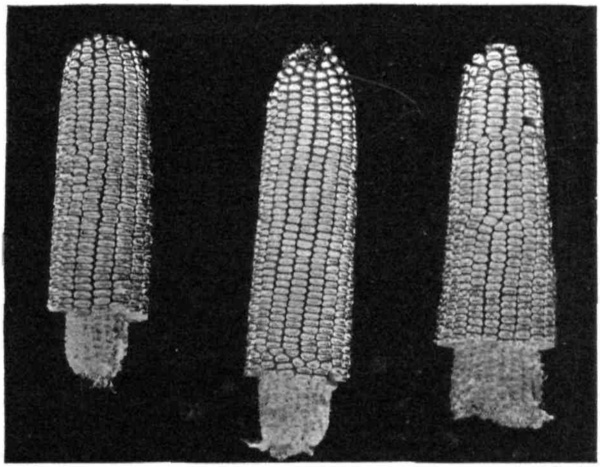
DENT VARIETIES IN THE EAST

Only a comparatively few varieties of dent corn are grown over any considerable range of territory. Probably the best known variety is the Leaming, earlier described in this chapter. The season is found to be long enough in New England for this variety, as it will mature in about one hundred and twenty days. It is quite generally grown in southern New England, both for the grain and for silage.

The Early Mastodon is a large-eared variety of white dent corn requiring a little longer season than the Leaming. The ears are about nine inches in length and two and five-tenths inches in diameter at the butt; kernels orange yellow with light yellow cap and rather loose on the cob; fourteen to eighteen rows; season one hundred and twenty-five to one hundred and thirty days. The growth of stalks is somewhat heavier than

for the Leaming. This variety is one of the best for silage in southern New England.

The Pride of the North is a dent variety that has been introduced from the west and has been grown over quite a territory in New York and southern New England. This variety has smaller stalks and ears than the Leaming. The ears are yellow; kernels rather loose; length of ears six to eight inches; diameter at



316 317 318

Fig 11—Large, Medium and Small Cob, Boone County White

the butt one and eight-tenths inches; season one hundred and twenty to one hundred and thirty days.

Benton corn is a long-eared, eight-rowed dent variety which has been so modified that it is now nearly of the flint type. As far as can be learned this variety was taken from Pennsylvania to Guilford, Connecticut, by a member of the Hubbard family, while a soldier of the American revolution. It is claimed that the corn

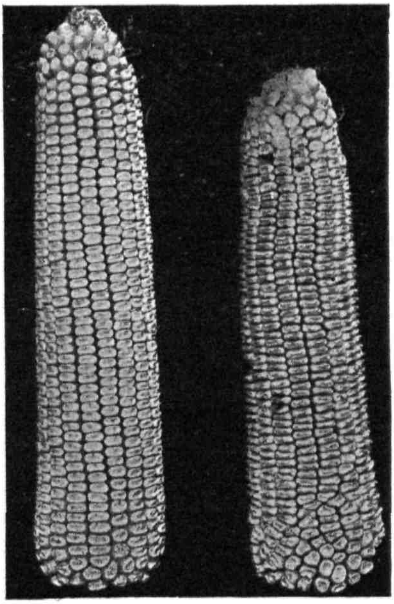
has been grown on the same farm by this family ever since it was first taken to Connecticut. The color is either cream yellow, or, in some instances, copper red. The kernels are of the flint type, except that they are slightly indented, although toward the tip many kernels are found free from dents. It produces the longest ears of any variety—fourteen to eighteen inches being common. The stalks are larger than most of the flint kinds, being eight to nine feet tall; the season is from one hundred and forty to one hundred and forty-five days. This variety is not generally grown outside the coast towns of Connecticut. The length of season is too long to make it a safe variety for seed north of this small area.

The following dent varieties may be mentioned among those grown in a limited way in New England and New York, but they are not widely enough known to warrant a description: Blount's Prolific, Butler's Dent, Farmer's Pride, Golden Dent, Hickory King, Horsetooth, Long Island Dent, Minnesota King, New England Dent, Sciota, Salzer's Ensilage, and Tyler.

FLINT VARIETIES IN NEW ENGLAND

The flint varieties are best adapted to New England on account of the short seasons and the smaller growth of stalks produced. Many of the older cultivated fields are so reduced in fertility that they will not carry to a normal development the larger growing dent varieties, and at the same time produce a good crop of grain. By heavy manuring any of the dent varieties which will mature in from one hundred and fifteen to one hundred and twenty-five days can readily be grown in southern New England, but for the states north of Connecticut and Rhode Island the flint varieties will generally produce a larger proportion of grain to stalks and are surer of reaching maturity.

From the earliest settlement of New England there has existed a yellow, eight-rowed, hard, flinty-kerneled corn with ears varying in length, according to the latitude, from seven to twelve inches. At the north this corn became known as the Early Canada. As a result of partial failures in the crop of one locality



322 323

Fig 12—Maturity, Boone County White

No 322, fully mature, sound ear; 323, immature, chaffy ear

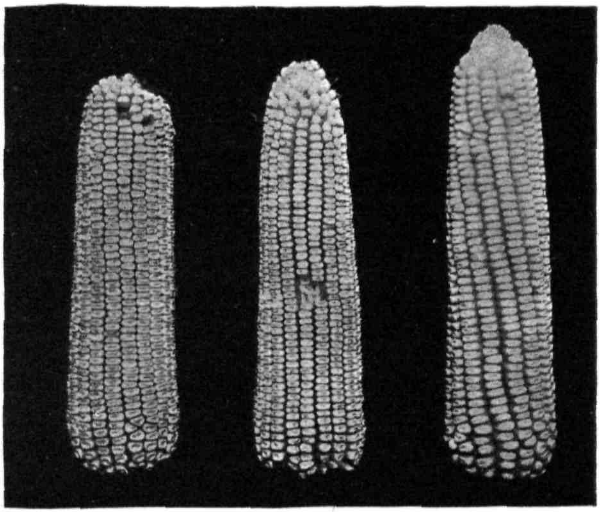
for a particular year, it became a common practice to send north and get corn from some point where the conditions favored a full crop, and to use this to im-

prove the local kind. The two kinds were seldom planted far enough apart to prevent cross-fertilization, and the result was a new type in the course of a few years. The tendency, in bringing a certain variety south, has been to shorten the season of growth, and then to gradually increase the size and length of the ears as the corn became acclimated. By slightly shortening the season of growth even partial failures became rare, and the same kind was thus maintained on one farm for a long period of years. These flint sorts were commonly known as Improved Canada Eight-Rowed, but after a time many took the name of the owner of the farm where they had been grown; as the "Asher Wright" corn, the "Brainard" corn or the "Warren" corn.

A good example of this type of corn is represented by the "Doolittle" Improved Canada. The kernels are large and firm on the cob; length of ear nine and five-tenths inches, diameter at the butt one and seven-tenths inches; ear tapering but slightly; hight of stalk seven to seven and five-tenths feet; season one hundred and ten to one hundred and twenty days. This general description will fairly cover the characteristics of several other varieties of Improved Canada flints of local repute, which have developed well-fixed types, by growing for a long period under uniform conditions. About the only differences found in many of these varieties are in the length and uniformity of the ears. The longer a variety has existed on one farm and the greater the care used in selecting the seed, the more uniform will be the ears. The white flint corn is essentially the same as the Improved Canada, except that the kernels are a pale cream-white, and are often more flinty than the yellow flints. The white flints are grown on some farms because they are preferred for making hominy. In the typical Improved Canada

white flint the ears are firm and the kernels large; length of ear nine inches; diameter at the butt one and five-tenths inches; ears slightly tapering and well capped over at the tips.

The Rhode Island White Cap is one of the best known varieties of corn in eastern Connecticut and Rhode Island. The stalks are small, rarely over six feet tall and commonly less. The ears are small, kernels very flinty and firm on the cob. The ears are five to seven and one-half inches in length and nearly always solidly capped over the tips. The diameter is about one and one-quarter inches at the butt and tapers but very slightly. The length of the season is one hundred to one hundred and ten days.



307 308 309

Fig 13—Space Between Rows

No 307, narrow; 308, medium; space 309, wide space

OTHER GENERAL VARIETIES OF CORN

Soft Corn—The soft corns are grown for the most part in the southern portions of the United States. The long season does not compel early maturity and the development of the hard covering which is the case with northern grown corn. This corn is not valuable for storing and is more subject to insect and other attacks. The freezing in northern latitudes rapidly destroys the life of the germ and the vitality is easily impaired.

Sweet Corn—Sweet corns were developed on account of their great amount of saccharine. Having a sweet taste they are peculiarly desirable for table use and are grown largely by market gardeners, canning concerns, and occasionally they are grown for forage.

Pop Corn is a peculiar type grown extensively in America on account of its composition. By heating the kernels, they pop open in a large fluffy mass. These varieties are described in detail elsewhere in this volume.

CHAPTER III

Plant Food

THE essential conditions of plant growth are: 1, plant food; 2, vitality; 3, moisture; 4, heat; 5, light.

In studying the principles of plant growth, it is important to understand what plants contain, and what are the sources from which they derive food. Plants are chiefly derived from air and from water. The greater part of a fresh or living plant is water. Young grass, for example, contains about seventy-five per cent of water and the more succulent vegetables contain a still larger proportion. This water comes from the soil: *i e*, it is taken into the plant through the roots. All the carbonaceous matters in a plant are formed from carbonic acid, which is taken into the plant through the leaves. Oxygen, which next to carbon is the predominant constituent of the dry matter in plants, comes largely from the air, though much oxygen comes to the plant in the form of water. Hydrogen also is derived from water. From the soil, plants take in that small proportion of inorganic matter, usually ranging between one and five per cent, which is left as ashes when the plant is burned. Although the proportion is small, the constituents of the ash are as necessary for plant growth as are those constituents which come from the air. It is from the soil also, through their roots, that all farm crops, unless it be legumes, take in the nitrogenous compounds which are needed for their growth.

Briefly, the elements of plant food obtained from the air and from water are: carbon, hydrogen, oxygen,

and in the case of legumes, nitrogen. From the soil the plant takes the following essential elements: phosphorus, nitrogen, potassium, calcium, magnesium, iron, sulphur and chlorine. Of these eight elements, calcium, magnesium, iron, sulphur and chlorine are used by plants in very small amounts and all ordinary soils contain them in such quantities that they are practically never exhausted. The elements contained in the organic portion of the plant are carbon, hydrogen, oxygen and nitrogen. These elements occur in approximate proportions as follows: carbon 45 per cent; oxygen 49 per cent; hydrogen 6 per cent. In addition nitrogen may be present in amounts varying from 0.5 to 1.0 per cent. The inorganic elements are phosphorus, potassium, calcium, magnesium, sulphur, iron and chlorine.

NATURE OF THE ELEMENTS USEFUL TO PLANTS

Carbon—Carbon is found in the earth in the form of a solid, as coal and diamonds. The compound of carbon upon which vegetation depends is carbonic acid. It is this acid in the air that feeds the plant. This compound is 1.53 times as heavy as air, and usually comprises about one-twenty-five-hundredth part of the air. No green plant can grow without the presence of carbonic acid. Although the carbonic acid of the air comprises but a small part of the whole, plants are able to secure enough to meet all of their needs. The supply of carbonic acid in the air is constantly replenished by the oxidation of organic matter, the combustion of wood or coal or peat, and by the respiration of all kinds of animals.

Comparatively little is known regarding the exact way in which the decomposition of carbonic acid is brought about in the plant. Experiments have shown

that light is necessary in order that decomposition may be effected; further, it has been proved that the process is in some way intimately connected with the green chlorophyl grains which give the characteristic color to leaves. However, the important facts are that the chlorophyl grains assimilate a part of the carbonic acid of the air and that the assimilated product is converted into the various components of the plant.

Oxygen—This element is a gas and comprises about one-fifth of the air. Oxygen forms a part of almost every compound that plants use as food, *e g*, water and carbonic acid gas.

Respiration in plants as well as in animals is supported by the oxygen of the air. The supply of this element, whether in free or combined form, is unlimited and adequate for the needs of plants.

Nitrogen—Nitrogen is a gas. It comprises about four-fifths of the atmosphere. Grain crops such as corn and oats can flourish only when their roots have access to certain compounds of nitrogen, namely, nitrates and ammonium salts. On the other hand, for leguminous plants it is essential either that nitrates shall be present in the soil, or that certain microscopic organisms having power to fix nitrogen from the air, live upon the roots and accumulate nitrogen upon which the plant can feed. The compounds of nitrogen which the ordinary farm crops use are taken into the plant, after being dissolved, through the roots. A limited amount of nitrogen is found in plants, but it is an absolutely essential element and the supply of it in many soils is quite limited. Moreover, nitrogen in a form available for plants is very liable to waste, being readily carried from the soil with the water of percolation. Therefore, nitrogen is one of the most

important elements of plant food and one which must be supplied to almost all soils, for all crops except those of the leguminous family.

Hydrogen—Hydrogen is a gas. It unites with oxygen and forms water. It is useful to plants only when combined with oxygen in the form of water. Hydrogen is a very important factor in plant growth, for the amount of water consumed by the growing plant is enormous. For instance, as stated above, water constitutes seventy-five per cent of many plants. The amount of water, however, found in the growing plant, is a very small proportion of the water required by the plant during the entire period of its growth. That this is true is proven by many experiments, which show that from 300 to 500 pounds of water are required by growing crops for every pound of the dried crop.

Phosphorus—This element unites with oxygen to form phosphoric acid. When a base unites with this acid, a salt is formed (phosphate) which is available plant food. The amount of phosphorus required by plants is not large, but the quantity found in most soils is so limited that this element of fertility often limits the productive capacity of many fields. In addition, the phosphorus which is taken from the soil by plants is largely stored in the seed or grain, and this is often sold from the farm. For these reasons phosphorus is a very important element of fertility from the farmer's standpoint.

Potassium—This element forms with oxygen a compound—potash, containing eighty-three per cent of the element potassium. It is this compound which is important in agriculture. Potash combines with an acid to form a soluble salt which is taken up by the roots of the plant. Some soils are deficient in potas

sium, and when this is the case, this element can be supplied with marked profit, either in the form of potassium chlorid or potassium sulphate.

The other necessary elements of plant food are usually present in the soil in sufficient quantities to meet all of the requirements of the plant.

The corn plant requires an abundant supply of all of these elements of plant food for maximum growth and production. The only elements enumerated above usually deficient in soils are nitrogen, phosphorus and potassium. Therefore the corn grower is chiefly concerned with the problem of keeping his soil well supplied with these three all-important elements of plant food in order that the productive capacity of his fields may be maintained undiminished.

No other question merits more thoughtful attention on the part of the corn grower than this one of the maintenance of the fertility of the soil. There is only one way in which this can be done, namely, by keeping good physical conditions and returning to the land all of the fertility which is taken off by cropping, and also that which is removed by the blowing, washing or leaching of the soil. There is no other way.

When phosphorus or potassium is lacking in the soil, if sufficient manure is not available to supply these elements in ample amounts they may be secured in the form of commercial fertilizers and applied directly to the land.

METHODS OF OBTAINING NITROGEN

It has been demonstrated, on the other hand, that the atmosphere is the most economical source of nitrogen for all general farming.

The leguminous crops, such as clover, cowpeas, soy beans and alfalfa, are most generally used in the various

sections of the United States for increasing the available supply of nitrogen in the soil. These crops not only supply nitrogen much more cheaply than any form of commercial fertilizers, but they are also valuable forage crops. They send their roots deep into the soil, and improve the mechanical condition of the land and by means of their extensive root systems bring plant food from the subsoil to the surface soil, where it may be used by future crops. The roots of the leguminous plants decay and add large amounts

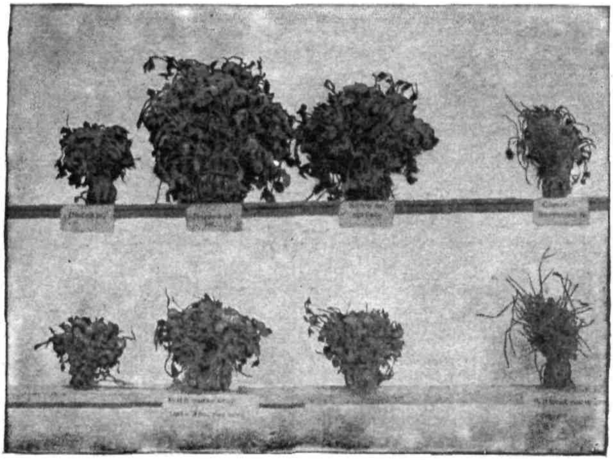


Fig 14—Samples of Clover
Taken from equal areas; different methods of seeding

of humus to the soil, which is an important factor in maintaining favorable physical and bacteriological conditions.

Clover has been grown in this country as a part of the crop rotation for many years, but not until the last fifteen years has its value as a soil fertilizer been fully appreciated. There are several varieties, adapted

to different conditions of soil and climate. Of these varieties the mammoth red, the medium red and the white clovers are most generally grown. The medium red clover is the variety which is most generally grown as a fertilizer for corn land.

The methods of seeding clover vary with the section of the country in which the clover is grown. There are three general methods of seeding for fertilizing purposes: 1, with nurse crop; 2, in corn, at the time of the last cultivation when the corn is laid by; and 3, alone, that is, without a nurse crop. Of these methods, the seeding with some nurse crop is in most general use. The kind of nurse crop varies with the agriculture of the country. In the great corn belt of Illinois, Iowa and in the eastern portions of Kansas and Nebraska, seeding clover with oats is the most common practice.

In this case the land is prepared for oats, usually by disking crosswise of the corn rows, if the land was previously in corn, then seeding the oats, and disking the field again the other way. The seedbed is then harrowed once with the ordinary floating harrow and the clover seeded, after which it is harrowed again crosswise of the previous harrowing. This method of preparing the seedbed provides a firm soil for the growth of the oats, which is to be desired, and also puts the ground into the best possible shape for the growth of the clover crop. In such cases the oats should be seeded medium to thin, as a very dense growth of oats interferes with the growth of the clover crop. With the ordinary varieties of oats, a seeding of one and one-half to two bushels of well-cleaned seed is sufficient. This will give a good crop of oats, protect the clover and not seriously interfere with its growth.

In this way a stand of clover can be secured without losing a crop from the field, an important consideration to the farmer. The clover seed is small and consequently contains little plant food. Therefore, it must be seeded shallow in order that the young plants may reach the surface, yet deep enough to get sufficient moisture for the best germination. It is extremely difficult to get good clover seed. Very frequently the vitality of the seed has been injured by cutting too early or by improper harvesting and drying. If the seed is moist it is liable to heat and injure the vitality of the seed.

Clover seed is very likely to be mixed with noxious weed seeds. The weed seeds are often of such a size and shape that it is impossible, or at any rate difficult, to separate them from the clover seed. For instance, buckhorn grows very much like the clover plant and matures seed about the same time. The seed is about the same diameter as the clover seed, and boat-shaped. In screening the clover seed these boat-shaped buckhorn seeds tip up and go through the clover screen, making it necessary to secure special cleaners. Other varieties of weed seeds are often found in clover seed, as smartweed, stampweed, quack grass and pigeon grass. All of these weeds are detrimental to the land, and clover seed infested with them should not be used under any circumstances. Such seed should be burned or discarded if cleaning is impossible and the land put in some other crop if good seed cannot be obtained.

The best rate of seeding is about ten to twelve pounds of clover seed per acre. Less seed will give a poor, thin stand, and more is likely to result in small, spindling plants, and the expense is increased. Poor seed should be sown more thickly than good seed, but quantity cannot make up for lack of quality. Poor,

Fig 15—Attractive Field of Cowpeas

weak seed will result in poor, small plants, no matter how rich and fertile the soil. The rate of seeding also varies with the soil. On poor soils the seeding should be heavier than on rich, fertile soils.

In seeding poor spots in the field or poor soils of any kind, it is well to apply a good dressing of well-rotted barnyard manure before preparing the seedbed. It is a good plan to seed early in order to give the clover plants all the time possible for growth before the hot, dry weather begins. In this case the plants will have matured sufficiently and be better able to withstand the unfavorable weather. Clover does not burn out so easily when the nurse crop is harvested.

Other nurse crops such as wheat, barley and rye are more favorable for clover seeding than oats. These crops grow more thinly on the ground and are less likely to lodge than oats.

In harvesting the nurse crop, cut as high as possible. The stubble offers some protection to the young clover plants until they become accustomed to the full heat of the sun. If the nurse crop is cut close to the ground, the sudden removal of the shade will often result disastrously to the clover plants, especially if the season be hot and dry. The earlier the nurse crop can be cut the better, as it removes the protecting shade before the sun attains full summer strength. It has recently been found that by growing a crop of rape in the oat crop, that the rape, growing very rapidly after the oats are harvested, tends to protect the clover plants. All fields so seeded, that have been reported, are said to have grown a fine stand of clover. Ordinarily the clover crop should not be cut the year it is seeded, but may be cut the second season and the second crop of that year plowed under. This permits the greatest possible development of the root system

and of the root tubercles. These root tubercles, with the power of taking nitrogen from the air, are the cause of the direct addition of nitrogen to the soil. The amount of nitrogen that can be added to the soil will depend on the number and size of the root tubercles. In other words, it is the object of the clover grower to produce as many root tubercles as possible.

The second method of seeding clover, i e, in the cornfield at the time of the last cultivation, is often successful and is the source of considerable benefit to the soil where a good growth is secured. The seed is usually sown broadcast and cultivated in when the corn is laid by. A little heavier seeding is desirable at this time, as part of the seed is lost among the leaves of the corn plants, and under ordinary conditions of soil moisture at this season of the year, a considerable proportion of the seed will not receive moisture enough for germination. If the season is very dry the seed will not germinate, therefore such a method will prove successful only when there is enough rainfall for germination.

The third method of seeding, i e, alone, without any nurse crop, is recommended for some sections, such as Wisconsin. In this case the use of the land is usually lost for one year. In most old cultivated fields there is such a supply of weed seeds in the soil that the weeds grow faster than the clover crop. These weeds use up as much soil fertility as a nurse crop without any return. Therefore the nurse crop system is preferred. If the clover is seeded alone, the seedbed should be prepared in the same manner, and seed sown at the same rate as when seeded with a nurse crop. However, in heavy soils it is often best to plow the land and to prepare the seedbed as for corn.

In plowing the clover sod for corn there are two methods used: 1, to plow under the second crop in the fall; 2, to allow the clover to get all possible growth in the spring and plow under just before corn planting time. The desirability of either of these methods will depend largely upon the age of the crop. If the crop is plowed under the first year after seeding it should be allowed to grow in the spring as late as possible, then be turned under to a good depth. The soft stems and roots will quickly decay, so that the corn crop can safely be planted in such fields. If the clover is allowed to grow one year on the field, it should be plowed under in the fall. In this case it will take some time for the stems and roots to decompose, so that it is necessary to plow in the fall to get a thorough disintegration. The field should then be thoroughly disked in the spring before planting the corn.

OTHER LEGUMINOUS CROPS

Cowpeas and Soy Beans—Clover seems particularly adapted to central and northern United States. For southern fields all the elements of a successful nitrogen gathering crop have been found in the cowpea and soy bean. Cowpeas are probably of Asiatic origin, being an article of human diet in India and China. The crop was introduced into southern United States and has rapidly spread until it is being generally grown as far north as central Michigan. The crop produces a large yield of very valuable feed and is one of the best for collecting atmospheric nitrogen.

There are many varieties, as a result of continued selection and growth on widely differing soils and under different climatic conditions. Of these varieties the most common are the Whippoorwill, Black, Red,

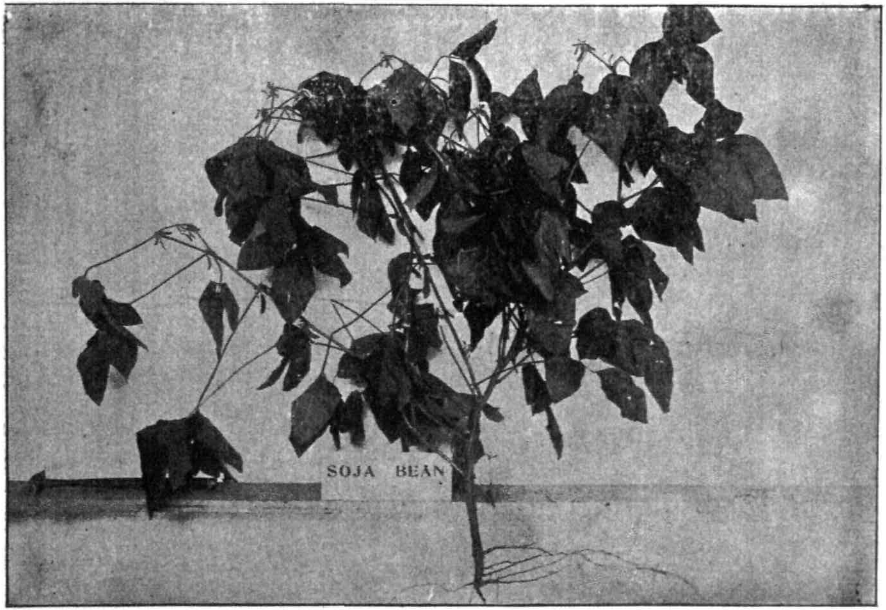


Fig 16—Good Specimen Soy Bean Plant

Clay, Black Eye and New Era. The Black Eye and Red are the favorites in central United States, while the Clay, Whippoorwill, New Era and Black Eye are most extensively grown under southern conditions. The Whippoorwill, Clay and Black Eye have particular trailing habits of growth, while the Black and Red are more bushy and upright growing varieties. The only objection to these crops comes from the fact that with present machinery there is some difficulty in planting and harvesting them. This difficulty will disappear when machinery especially adapted to the handling of these crops comes into general use. In localities where live stock farming is practiced these crops are generally used for soiling or for pasture.

The seedbed for cowpeas is prepared as for corn, by plowing medium to shallow and thoroughly pulverizing the ground. The cowpeas are seeded broadcast or in drills, the drill being most satisfactory because the fields can then be cultivated. In drilling, the rows should be about thirty inches apart and the seed from two to four inches apart in the row. If the crop is grown for seed the rows should be from thirty to thirty-six inches apart, with the same number of seed in the row as in the thirty-inch rows. In this case it will be necessary to use about one-third of a bushel of seed per acre. The cowpeas should be drilled in to a depth of two or two and a half inches, and care should be exercised not to exceed this depth. The field should be cultivated with weeder or harrow until the young plants come up. This will prevent the starting of weeds. This is the most important point in all cowpea cultivation, as the weeds will quickly check the growth of the cowpeas and cannot be removed without hand labor after they once get a start.

When grown simply for soil fertilizing purposes, the crop should be plowed under in the fall; it will decompose before spring and be in shape for feeding the corn plants. When it is desirable to save the crop, it can be cut with the mower, cured and the seed threshed with an ordinary separator. Part of the concaves and teeth should be removed and the machine run slowly in order not to break or injure the seed. If the seed is to be used for future planting, it should be dried before storing away in a bin. Otherwise it is likely to heat and the vitality be destroyed.

Before planting the seed it is absolutely necessary to test the germination or vitality of the seed. Select samples of fifty seeds from ten representative places in the seed bin and mix together. Take out two hundred seeds and test in the germinator. Experiments in growing corn on cowpea land prove that cowpeas are very valuable soil fertilizers. This crop is rapidly extending to all corn growing sections. By drilling in cowpeas between the rows of corn after the last cultivation a considerable growth can be secured and the fertility of the soil increased. When cowpeas are so seeded, they should be drilled in between the rows of corn or sown broadcast at the time of laying the corn by. These cowpeas generally will not mature, but the fertility of the soil will be improved.

Soy beans are grown by the same methods as cowpeas. They seem to do fairly well in the winter wheat section of the United States and southern Canada. There are several varieties, the most common of which are early yellow, medium and late soy beans. The early yellow and the medium will mature in northern United States, the late in the southern sections.

This crop is frequently planted, as is the cowpea, by drilling in with the corn planter. In this case large

enough plates should be used in the planter boxes to drop one or two seeds every two or three inches. If a seed crop is desired, drill the rows the ordinary width of the planter rows. If a forage or soil fertilizer crop is the object, straddle the planter rows so that with the ordinary three feet six inch planter the rows will be twenty-one inches apart. This method can also be used for planting cowpeas, care being taken that the planter plates do not break the beans or peas.

The soy bean or coffee berry, as it is sometimes called, grows in an upright bushlike form, the pods containing three or more seeds. From the peculiarity of growth it is possible to harvest them easily and as a result they are extensively grown for feeding purposes. If a good stand is secured, the soy bean will produce a large crop. If they are to be used for hay, they should be cut early in the season before the seeds are ripe and before the leaves have begun to fall. This will prevent, in a large measure, the formation of a hard, woody fiber, which is present in the matured plants. As the plants are frequently harvested early in the season before the seeds are fully matured and dried out, and the seed stored in this condition, it frequently happens that the pile of seed heats, and the vitality is destroyed. It is absolutely necessary to test the vitality of all soy bean seed before planting.

By moving the crop north gradually, the plants are so changed in their habit of maturity that they become acclimated. At present great crops of this soy bean are annually grown as far north as northern Michigan. As a result large tracts of clay and sandy soils are being greatly improved in productiveness. It has been found from many experiments that soy beans are very valuable soil fertilizers for corn and that a crop of corn grown on soy bean land yields

many more bushels per acre than corn grown on the same land not fertilized by soy beans.

Alfalfa is a crop which is widely grown in western states. In Kansas and Nebraska corn grown on alfalfa land gives splendid returns. The alfalfa roots penetrating the soil to a great depth, loosen the subsoil, and bring the soil fertility to the surface, where the corn plants can make use of it. Further, it adds to the supply of soil nitrogen and in this way prepares the soil for the corn crop.

The only difficulty with alfalfa as a crop to be introduced into a corn rotation is that there is considerable trouble in securing a stand. Moreover the crop does not reach its full producing capacity until about the third year after seeding. This being the case, the alfalfa crop is usually allowed to stand for several years, in some cases as long as fifteen to twenty years. As many as four crops are frequently harvested each year. If these are taken off the soil and no manure returned, the land will eventually be drained of its fertility. As it is desirable to have something which can be seeded and a crop obtained the first year, alfalfa is not likely to come into general use as a part of a corn rotation.

BARNYARD MANURE

For enriching a soil for corn, barnyard manure is a most valuable fertilizer. The application of barnyard manure increases the amount of available fertility in the soil, adds to the humus content, and improves the mechanical condition of the soil.

Therefore, the preservation and application of manure is an important problem with the corn grower.

The conditions affecting the saving and preservation of the elements of value in manure, have largely to do with the value of manures. An effort should

always be made to handle manure in such a way as to reduce to a minimum the loss of valuable constituents.

The chief sources of loss are: first, through the escape of the liquid portion of the excrements; second, by leaching and exposure to rain; third, by fermentation. Excessive fermentation results in the serious loss of nitrogen; the escape of the urine results in the loss of nitrogen and potash.

When possible, an abundance of litter or bedding should be mixed with manure, to prevent loss from drainage. The manure should be kept so as to prevent washing and leaching; compact and moist to prevent too rapid heating. It should be kept compact, also, to prevent too rapid formation of nitrates. It is true that it is in this form that the nitrogen in the manure is available for the corn crop, but this change into the nitrate form can go on far more safely in the soil than in the manure heap, for in the latter the nitrates are likely to suffer loss through the action of the nitrate-destroying bacteria present in the lower portions of the heap.

Should manures be applied fresh or rotted? The important points relative to applying fresh manure are: first, the earlier manure is applied to the field, the less is the loss of plant food; second, fresh manure furnishes more humus to the soil than that which is well rotted; this is true because in the process of decay a portion of the organic matter is destroyed; third, on a majority of farms, the amount of work is comparatively light at the season of the year when the greater part of the manure is produced and it is often a source of economy in getting out the manure to spread it as fast as it is made.

The objection may be offered to this plan that the manure suffers serious loss from lying upon the sur-

face. In this connection it is well to remember: first, that the proportion of soluble constituents in fresh manure is less than in rotted; second, that fresh manure does not contain any considerable amount of ammonia.

When fresh manure is spread in the winter, before the nitrogen of the urine and dung is converted into ammonia by the process of decomposition, there is little or no loss into the air; further, ammonia will not form when the temperature reaches the point which usually prevails during the winter months.

There is one possible source of serious loss, however, when manure lies exposed on a sloping or hilly surface. Under these conditions a portion of the soluble constituents of the fresh manure may be washed out and carried away over the surface. It is generally preferable to spread manure on pasture, meadow or stubble ground where there is less danger of washing and consequent loss.

On the other hand, well-rotted manure is a highly concentrated product. Certain anaerobic ferments act to destroy the woody fiber in the manure and thus the proportion of nitrogen, phosphorus and potassium, the valuable fertilizing elements, may be larger in well-rotted manure than in the fresh manure. This shrinkage in volume, which occurs when manure ferments, is an important saving in the cost of distributing the product upon the field.

Thoroughly rotted manure is esteemed highly because it may act more quickly than fresh manure. A large proportion of the elements of fertility are in a condition to be taken up by the roots of plants. In addition the humus of well-rotted manure would in case of drouth, serve a better purpose than that of fresh unfermented litter.

Use of Manure Spreader—In spreading, it is a great advantage to use an improved manure spreader, for this machine will scatter manure evenly over the field.

If the spreader is carefully housed and cared for, it should prove serviceable for a long term of years and should soon pay for itself on an average sized farm.

The even distribution of finely divided manure is of great importance. When manure is left on the surface in heaps of various sizes it often proves an absolute injury to the soil. The plants growing on the excessively fertile spot are inclined to develop an abnormally large growth of stalk or stem and to yield comparatively little seed.

CHAPTER IV

Breeding and Selection of Seed Corn

CORN breeding has become a specialized industry. Like stock breeding, the development of corn varieties will always be more or less in the hands of a comparatively few men who devote their lives to this particular work. All great progress will be made by those especially fitted for work of this kind. As the field is broad and the results profitable many will engage in the business of seed corn production.

The general farmer will never breed corn. He must secure seed from the specialist and from this source procure improved strains. Eventually on the average farm the valuable characteristics will be lost through mixing and careless selection. Then it will be necessary to secure a supply of seed corn from a corn breeder. In such cases the farmer must secure such strains of corn as are adapted to his conditions of soil and climate. Otherwise the beneficial effect of the special breeding may be lost. The live stock breeder usually cannot afford to breed corn and will depend for the most part on the corn breeder for his seed.

The field for this branch of farming is very great, as is shown by the fact that the corn growers of Illinois alone use over one million bushels of seed every year. The corn growers of the United States use annually over fifteen million bushels of seed corn. Of course, it is not necessary that this seed be secured from the breeder fresh every year, but as a rule seed

will not remain pure more than four or five years. It then becomes necessary to again secure well-bred seed. As yet the demand has been but little developed. Farmers are just beginning to realize the importance and benefit of improved seed, but even now corn breeders are not able to supply the demand. That this demand will increase far beyond the capacity of corn breeders to supply, there is no doubt.

Fig 17—Corn Silk
Greatly magnified, showing grains of pollen adhering

The advantages of improved seed corn are numerous and the grower quickly reaps the benefit. For instance, improved corn tends to diminish the percentage of barren stalks. This is important because the barren stalks represent a direct and great loss to the corn grower. Statistics secured with great care show that the loss caused by barren stalks, in many fields, approximates ten and even fifteen per cent.

Again it is true that in the average field the ears of corn are not uniform in size. Only a small proportion are large. The majority are irregular, many being very small and stunted. It is the function of the corn breeder to increase the uniformity of the crop by selecting and preserving only the best ears. The proportion of corn to cob, the shape of ear, the filling out of ends, are all subject to the breeder's influence, so that by continuous selection of a uniform ear an improved type may be raised for the benefit of the grower. This benefit is out of all proportion to the increased cost of seed for improved strains. In buying an ear of corn, the growers get a thousand individuals capable of reproducing themselves in one

year. The live stock breeder, on the other hand, pays a great amount of money for one individual which requires a mate.

In years past little attempt has been made to systematically improve corn. The corn plant was but little understood. In fact, the whole field of corn development is practically unexplored. Enough is known, however, to show the boundless possibilities and in a general way to direct the work of the breeders to some definite end. Following will be given an outline of the methods now in use. These are the result of the experience of the past and the study of the present.

APPROVED METHODS OBSERVED IN BREEDING

There are two grades of seed corn—the highly-bred seed and the stock seed. The highly-bred seed can never exist in large quantities and will consequently never enter into the commercial transactions of the corn breeder to any great extent.

By highly-bred seed is meant seed that represents the best of the improved types. In other words, those ears which as nearly as possible represent the ideal ear. As every ear is different from every other ear, there can never be a large number of such ears. However, this very fact of wide variation makes the improvement of varieties possible. If there was no variation from which selection could be made, there could be no improvement. It is by selecting those ears which vary in the direction desired and discarding the poor ears that a general advance can be made.

The stock seed is the corn one generation removed from the highly-bred seed. The corn breeder will concentrate his main effort in the production of highly-bred seed. From this seed large quantities of stock seed may be grown and sold to the farmers. This

seed possesses nearly all the good points of the highly-bred seed, and differs only in the fact that individual selection by the corn breeder has ceased. This kind of seed can be produced in large quantities and can be sold at a moderate price. No farmer, however, can afford to depend on imported seed for the main part of his crop. Seed corn imported from

Cross-bred Self-fertilized

Fig 18—Effect of Inbreeding

Small stalks inbred; large stalks cross-bred

a distance and especially from a different latitude seldom gives satisfactory results the first two or three years, even though the seed may be of the best, which oftentimes is not the case. It is well known that most of the seed corn put on the market by seedsmen is bought of farmers in crib lots, shelled, screened and

sacked, ready for sale, little or no attention being paid to the selection; in fact, it is generally handled with a scoop shovel and is known as the "scoop shovel method of selection." The chances are that the farmer has in his own crib better corn than that which he purchases from seedsmen at four or five times the market price. And then he runs the additional risk that it will not mature in his locality. If it were simply a matter of losing the price of the bushel of imported seed corn, it would not be serious, but when we consider that a bushel of seed corn ought to produce four hundred bushels of corn worth from $130 to $160, the serious nature of the question is very apparent. If for any reason a farmer's corn is not satisfactory for seed, he certainly should not send away for seed corn, but should purchase from someone in the vicinity whose corn has given good results during the past three or four years. It is an excellent plan, however, for two or more persons in a neighborhood to secure a small amount of good seed of some of the standard varieties and give them a good trial. In this way it is probable that varieties will be found which, after they have become acclimated, will prove of considerable value to the community.

The selection of the variety is the first important point in breeding seed corn. The variety must be adapted to the conditions of soil and climate in which it is to be grown. Of course, by reason of the great variation in corn, varieties suited to almost any conditions may be chosen, but in order to save time it is wise to begin with a variety already adapted to the conditions. It takes considerable time to effect any marked change, consequently a variety which has been thoroughly tested should be selected. There will be ample opportunity to make any desired changes, and by taking advantage of the previous breeder's effort

much time may be saved. If a mongrel or impoverished strain be selected, it will require years of the most careful work to get the variety ready for definite improvement. In other words, it will require years to eliminate unfavorable characteristics. For the same reason it is not wise to select a variety the result of a recent cross. There is already so much variation in corn that it is not desirable to begin with a corn which has the characteristics thrown together in confusion. It is better to select one with the characteristics sorted out, and then give them definite direction by selection. Otherwise the undesirable characteristics will crop out from time to time, and will hinder improvement.

The color of the variety is unimportant, except that there is frequently a prejudice in favor of a particular color in a neighborhood, or among a certain class of corn growers. A farmer who has always grown white corn is apt to fancy that color, and vice versa. In any case, the breeder must select a color that he desires and likes, and which most nearly meets the demand of his market. Otherwise, he will not so readily become attached to his particular strain. It is unwise, however, to begin with any variety which is unusual, as a striped kernel; it is more judicious to select a solid, deep, strong color.

In every case it is very important to begin with a corn which has possibilities for marked improvement. It is essential that the variety have a good-sized kernel with large germ, a medium to large cob, and a well proportioned ear. In the flint corn, however, a medium to small ear is usually preferred. It is easier to eliminate undesirable features than to build up absent ones. It is also extremely important that the variety have a large, well-developed stalk with broad leaves, and an extensive root development. These provide for the development of the ear, and

make it possible to bring about almost any desired improvement.

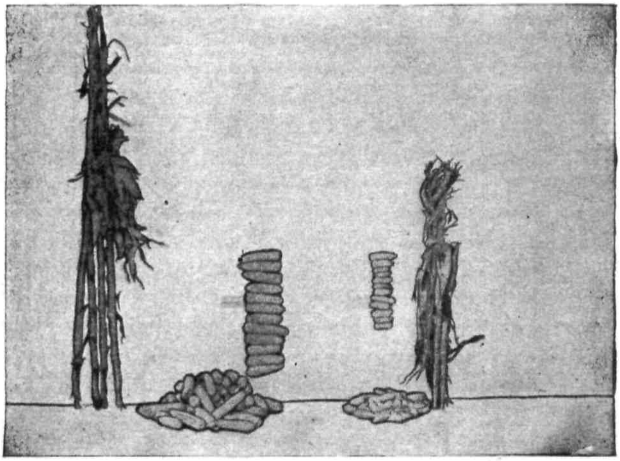
Influence of Soil on Development—The soil upon which the corn is to be grown has a very important influence on the character of the variety. A poor soil, or a soil deficient in any element of fertility, or one which is in poor mechanical condition, will produce poor stalks and poor ears. On the other hand, a soil having the proper proportions of the elements and handled so as to be in the best possible mechanical condition, will give the best results. It is further necessary to rotate the crops on the soil. If corn is grown year after year upon the same field, numerous insect enemies accumulate and little opportunity is given for the development of corn. The ideal conditions of soil seem to be the prairie loam of the Mississippi valley, so rotated as to include leguminous crops, and the judicious application of manure. If the soil is found to be lacking in any essential element the deficient element should be applied in some way, as by commercial fertilizers.

Thorough under-drainage is absolutely necessary for a successful corn breeding field. This is true in order that the best possible mechanical condition be maintained. All superfluous water is drained off quickly and the soil is then prepared to hold moisture against a summer drouth. The preparation of soil and cultivation of the fields should be consistent with good practice for the particular neighborhood in which the corn is grown. It is possible that extra surface stirring will be found profitable and useful during the summer in order to conserve all possible moisture. One important point is to plant the corn immediately after the seedbed has been prepared.

The thickness of planting must vary with the fertility of the soil and with other conditions. The

general rule is to plant few kernels in the hill far enough apart to admit of the best possible cultivation. The usual distance is three feet six inches between the hills, and to plant three kernels in every hill. If three stalks is too great a number, one or more can be pulled out early in the season, and the field thinned to the number desired.

Breeding Field—The field for the highly-bred corn must necessarily be small. This is true because



Cross-pollinated Self-fertilized

Fig 19—Effect of Three Years' Inbreeding

Large stalks and ears cross-pollinated; small stalks and ears inbred

there must be individual selection and a large field would make the most careful attention impossible. On the other hand, a small field will allow all possible intensive selection. A good sized field for this purpose is about an acre. This must be so located as to prevent mixing. As the pollen from corn will float

about in the atmosphere for at least a quarter of a mile, or farther, it can be seen that this breeding plat must either be located far away from other cornfields or protected in some way. This protection may be given by a hedge or other obstruction, or the breeding plat may be located in the field of the same variety. If this last plan is adopted, the field should be planted from highly-bred or stock seed, so that the corn breeding plat will not be fertilized by the pollen from inferior stalks of corn. The best plan, if possible, is to isolate the breeding plat. The breeding area must be so planned that every seed ear is planted in a definite space. There are two general ways of doing this and both give satisfactory results. Whether there is any special benefit in either plan is not known, and it remains for future experience to demonstrate the best methods of planting. The two systems are called the "plat" and the "row" systems. In the plat system a plat, usually ten hills square, is planted from a seed ear. The plat is definitely located; any remaining kernels on the ear are preserved, properly marked, for future reference. The plats are arranged in a square, to allow the greatest possible amount of fertilization within the plat. The accompanying diagram shows in general the arrangement of the plats:

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

Breeding Plats Arranged in Squares

1. ....
2. ....
3. ....
4. ....
5. ....
6. ....
7. ....
8. ....
9. ....

Breeding Plats Arranged in Rows Each of One Hundred Hills

The three thousand six hundred hills make a convenient number and can be enlarged or decreased at will of the breeder. The object is to secure the number which will give enough seed for producing stock seed, and yet small enough so that every ear can be carefully studied before a final selection is made.

The method employed in the work is as follows: In the fall, the ears from each plat or row are put into separate bags and taken to the seed house. In all cases ears should be selected only from well-developed and strong stalks. The bags should be numbered to correspond to the rows from which the corn has been husked. Each bag of corn should be laid out separately, weighed, and the number of ears true to type and of the kind desired picked out and laid by themselves. The ten rows or plats producing the largest yield and number of ears of the type desired must have been planted from seed prepotent for the production of that type. Now, if the seed for the next year's seed plat be taken from these plats or rows, this prepotency will be taken advantage of and preserved. The rest of the corn can be used to plant the fields for growing stock seed.

Barren Stalks in Breeding Plat—During the summer the breeder should go through the breeding plat

and cut out or detassel all poor or dwarf stalks which later might prove to be barren stalks. This should be done just as the tassels are coming out, and before any of the pollen has been shed. This plan will prevent the seed being fertilized by the pollen of these undesirable stalks.

Corn is Cross-Pollinated—Corn is cross-fertilized. The silks on a stalk generally mature at a different

Fig 20—Effect of Four Years' Inbreeding
Small row inbred; large row cross-bred

time than the pollen and thus the pollen of one stalk fertilizes the silks of other stalks. Careful estimates show that a well-developed tassel may produce as many as thirty to sixty million pollen grains. These pollen grains are wafted by the wind about the field, and if blown upon silks which are ready for fertilization they will attach themselves to them and perform the function of fertilization. This production of pollen is an enormous draft on the strength of the

1. . . . .
2. . . . .
3. . . . .
4. . . . .
5. . . . .
6. . . . .
7. . . . .
8. . . . .
9. . . . .

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plant. By removing the tassel at the proper time, so as not to injure the plant, and allowing the ear to be fertilized by other pollen, the ears on such detasseled stalks are better developed than the ears on the stalks not so detasseled. By detasseling two rows and leaving two rows with tassels, enough pollen will be provided for the complete fertilization of the field. See Fig 22, illustrating pollen grains greatly magnified.

The Illinois experiment station found that by inbreeding, that is, placing the pollen of the stalk upon the silks of the ear on the same stalk, the size of the ear and stalk would be eventually decreased. In other words, it is evident that inbreeding in corn tends to develop weakness and a general deterioration of the vitality of the plants.

Corn naturally crosses within the variety. Evidently there is little danger from the evil effects of inbreeding, in the judicious selection of seed from one variety or strain.

Corn intended for seed should be allowed to thoroughly mature on the stalk or in the shock before it is gathered. It is then important that the corn should be placed in a crib where there is thorough ventilation. If it is placed in a warm room there is danger that the corn will begin to germinate or mold as a result of the moisture and the warmth. By the middle of November it is best to transfer the corn to the seed house where some artificial heat can be applied for at least a few days until the corn is thoroughly dried. Often it is advisable also to warm the room occasionally during damp spells or during extremely cold weather. In ordinary seasons fire drying is not absolutely necessary, but is a precaution which it is wise to adopt every season.

The best plan to date is to place a single layer of ears in the seed room on two strips raised a few

inches from the floor to permit the free circulation of air. This seed room should be sufficiently large to admit of storing all the seed corn. This row of ears should be put down carefully, all ears being turned the same way. Now place a second layer on top of the first, reversing the position of butt and tip, so that the butts of the ears on the second layer will rest on the tips of the ears of the first layer. Lay two more sets of ears in similar position on top of the first two. Then place a one-by-one-inch piece on each side, one on tip and the other on butt. In order to do this it will be advisable to have upright two-by-four pieces set along the row about eight feet apart. These small side strips can then be tacked on either side of the upright pieces. This will permit the piling of the corn from the floor to the ceiling, admitting of the storing of a very large amount of corn in the smallest possible space.

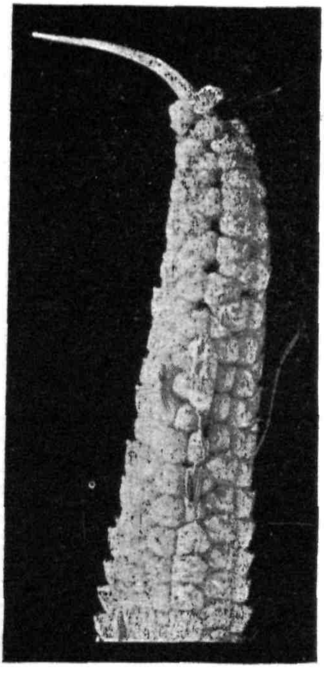


Fig 21—Illustrating Young Ear of Corn Before Silking
Magnified

It is convenient to have a small stove set in the middle of the room so that on damp, cold days a slight heat will dispel all moisture and remove all

danger from freezing. When the corn is to be taken down the top layer should be removed first, and so on until the entire section is removed. A space of two feet, or any convenient distance, should be left between every section so the air may circulate freely and the corn can easily be inspected at any time. All windows, etc, should be battened securely so that no snow or rain can drive in during storms.

Fig 22—Pollen Grains on Silk
Greatly magnified

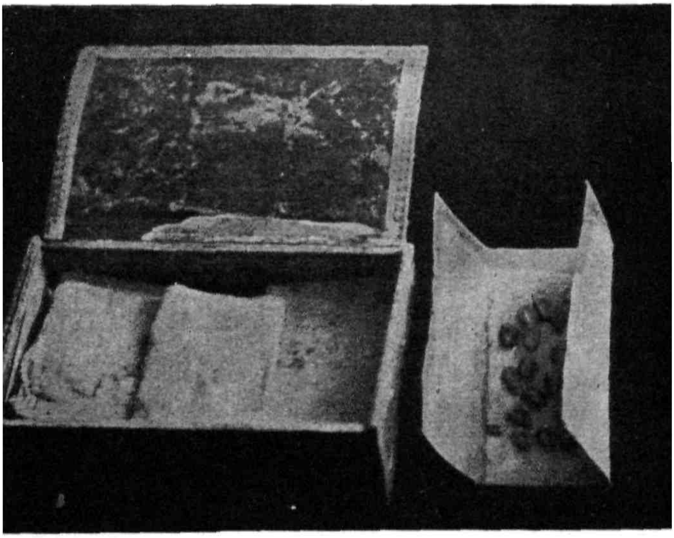
Selection of Seed Corn—At husking time the corn should be brought from the field and placed in the general crib. Here all of the corn should be scooped on a table and carefully sorted by an experienced man. The rejected corn can then be piled in one end of the crib and the seed ears taken to the seed house and placed in the racks as described in the preceding paragraph. During the winter the ears can be taken down and packed for shipment. All seed corn should be shipped in the ear, and it will not be many years until it will be impossible to sell shelled seed in the case of corn to be used for breeding purposes. A most convenient method of shipping is to wrap each ear in paper, and put the ears in a box which will hold about one bushel.

This box or crate can be purchased of box factories, or the seed grower can make it himself at a

slight expense. A sugar barrel is convenient for packing large shipments.

Shipping Seed Corn—In any event, the greatest care should be taken that the seed corn reaches the customer in the best possible condition, with no injury to the ear. It is also desirable that care be taken to groom the ears, by removing all shanks or husks, and the ear be made to present the best possible appearance.

Testing Seed Corn—It is imperative that all seed corn should be thoroughly tested, and given a germination test of not less than ninety-four to ninety-five per cent.



(By courtesy Iowa Experiment Station)

The above cut illustrates one of the most convenient methods for testing the vitality of seed corn.

Fig No 1 shows the box in which are placed folders containing samples of corn to be tested. Fig No 2 shows a folder ready to put in the box after the edges have been folded down over the corn. Any box will answer the purpose although the cigar box represented in the cut, or a wooden one like it, is preferable.

The folders should be thoroughly moistened before placing the corn in them. Put four or five thicknesses of moistened paper in the bottom of the box and as many more over the samples to prevent drying out. Then shut the cover and wrap a string around the box to hold the cover down to prevent the corn from drying out, and set away in the sitting room or some place where the temperature does not fall below fifty-five degrees. The best folders are made by taking five or six thicknesses of newspaper and cutting the strips about five by ten inches and folding as shown in the cut. The only precaution necessary is to be sure that the folders are thoroughly moistened before the corn is placed in them for testing. In two or three days it will be well to examine the corn and if the folders are getting dry, they should be moistened by sprinkling water over them in the box. At the end of five days the sample should be taken out and examined carefully. Every kernel that has not at this time sent out vigorous root and stem sprouts should be counted unfit for seed. The corn ought to test not less than ninety-four to ninety-five per cent. This method has the advantage of requiring very little attention and makes it possible to see whether the kernels are making a uniform and vigorous germination, which is very important. Kernels which make a slow, feeble germination are not fit to plant. The practice of unscrupulous seed dealers in the past has justly prejudiced many people against the use of imported seed corn. In many cases the corn

was poor in quality and of no particular selection, so that the results were unsatisfactory. This condition of the seed business cannot long continue and consequently such dealers will be rapidly driven out of business. With improved seed, increased yields may be expected and a more uniform and satisfactory type of corn will be produced.

Sorting and Preparing of Seed Corn for the Planter—Probably there is no better way to sort and prepare the seed corn than to place forty or fifty ears on some boards or tables and with all the tips pointing one way. Select an ear that most nearly represents the type you prefer. With this ear in your left hand, go over all the ears on the board and with the right hand push out those ears which show too great variation from the type in size, length, shape, roughness, color, size and shape of kernels, etc. Now gather the few remaining ears together, and, with a knife, remove three or four kernels from each ear and place in front of each ear, with the germ or chit side up. Now go over these kernels carefully, for here is where we have failed most in the past. We have studied the ears, but have paid little attention to the kernels. First discard those ears which have kernels unusually broad, long or thick, also those which are very narrow, thin or short. This is absolutely necessary before we can expect any planter to drop a uniform number of kernels in each hill. Discard all ears with kernels which are shriveled, or are too pointed, indicating low vitality and poor feeding value. The butts and tips should now be shelled off and the ears shelled as above described. But this is not all. This corn is not ready for the planter until it has been picked over by hand, removing the broken, rotten, discolored, irregular, weak and chaffy grains. This seems like a

great deal of expense, but no farmer can afford to do less than this.

When we remember that it is possible for a bushel of seed corn to return us seven hundred bushels next harvest, we can readily see the folly of neglecting this work. What is a day, or even two days, spent on this bushel of seed corn, and especially at this season of the year?

CHAPTER V

Corn Judging

THE great object which the judge has in mind is to select that sample of corn for first place, which in his estimation, is best for seed purposes, namely: which will if planted next spring give the greatest profit per acre in the district in which it is grown.

There are a number of things which the judge takes into consideration in scoring or marking the samples. In the first place the samples will be laid side by side on a table or long plank so that they can be studied carefully and compared. Two or more kernels are taken out of each ear and laid at the tip of their respective ears with the germ or chit side up. In case there are any poor samples which for any reason stand no show of winning they are laid to one side without spending any more time upon them. The judge then scores the remaining samples, taking up one point at a time, and marking each sample what he thinks it deserves on this particular point and so on until the samples have been marked or scored on all the different points. The score for each sample is then added and the one with the highest score receives first place, and the next highest second place, and so on.

History of the Score Card—There are certain general points in all varieties of corn which must be taken into consideration by the judge and the breeder. This has led to the formulation of these general points in a so-called score card. In this standard of perfection for corn the corn growers have given the

different points in an ear of corn their proper degree of importance. It is an invaluable guide to the judge in keeping in mind during judging a proper sense of the proportional importance of the general points, so that peculiar characteristics are not given undue importance. A score card for corn was first formulated by the late Orange Judd and was recently modified and revised by the members of the Illinois corn growers' association. This lead was immediately followed by other score cards made by the corn growers' societies of other states. At present there are several in existence. Further changes will doubtless be made in the score card, adapting it to future requirements.

VARIETY STANDARDS

Each particular variety has its characteristic shape, etc, which must be known by the judge in order to properly pass upon the exhibit. Further, each variety has its peculiar length, circumference, and proportion of corn to cob. These points, determined by a careful study of the best samples of the different recognized varieties, are as follows:

	Length, inches	Circumference, inches	% corn to cob
Leaming	10	7.0	.88
Boone County White	10	7.5	.86
Silver Mine	9	7.0	.90
Reid's Yellow Dent	10	7.0	.88
Riley's Favorite	9	7.0	.90
Golden Eagle	9	7.0	.90

PRACTICAL JUDGING HINTS

In judging corn, it is the custom to use ten ears for a single sample. This number furnishes the most

simple and easy calculation, and has been adopted as the standard number for all exhibitions. It is very desirable that the exhibits be so arranged that the samples can be laid out side by side on a table with a few inches of space between each sample. It is convenient for the judges to work on a table about three feet high and it is imperative that there be a good light on all sides of the samples. The samples should be handled as little as possible during judging, care being taken that no kernels be knocked off by careless dropping of the ears. Any kernels that are missing are usually regarded as mixed and the usual cut made for such imperfection. However, it is allowable in selecting a sample for an exhibit to remove two kernels from near the middle of the ear for the purpose of studying the shape, size and general characteristics of the kernels. Danger of injury can be avoided in shipping by carefully wrapping each ear in paper or other protection, and packing the ears firmly in the shipping box.

Corn should never be sent to any exhibition in a basket or bag, as there is always great danger of damage from careless handling. It is always allowable and perfectly proper that the exhibitor take special pains in preparing the exhibit for the judge. All silks and shanks should be carefully removed and the ears groomed so as to present the best possible appearance. However, it is not allowable to mutilate or cut the ear itself in any way. Any ear with the protruding tip cut off should always be cut to the limit, as the presumption is that the tip was very poor or it would not have been cut off. Neither is it allowable to remove mixed kernels and substitute kernels of proper color. Changes of this sort can usually be detected by the expert judge, and a full cut for color for that ear should be made.

The shape and other characteristics of ears will vary with every variety. It is the function of the expert judge to know the variety characteristics and to score accordingly.

HOW TO STUDY THE EXHIBIT

Shape—The shape of the ear should conform to the variety type. With most of the varieties it is important that the ears should not be slender nor taper too rapidly, as this indicates weakness or lack of constitution; rather have the ears full in the middle, carrying their size well up to the tip, rounding over quite rapidly. This shape allows the development of uniform deep kernels from butt to tip and usually results in a large percentage of corn to cob. However, the characteristic Leaming ear is partly cylindrical, that is, cylindrical for part of its length at butt and then slowly tapers to tip. This is usually the result of dropping two or more rows of kernels, about one-third the distance from butt to tip. In the Leaming variety this characteristic shape is not particularly objectionable and no cut should be made for such condition. Another objectionable shape is the tapering ear, which begins to taper at butt and runs out to a sharp-pointed tip. Such shape is always objectionable from the fact that the butt kernels are large and the tip kernels very small, usually the case in an ear with a small percentage of corn to cob. The exhibit showing the best variety shape should be given the full number of points.

Uniformity—A uniform exhibit means a sample, all of the ears of which have the same size, shape, type and general characteristics. This is one of the most important points in the score card. A uniform exhibit shows good breeding, while an irregular exhibit shows poor selection. In judging uniformity

the characteristics of the ear must be taken into consideration. The indentation of the kernels, color and straightness of rows must be particularly taken into account. The rows should be parallel from butt to tip. If they are crooked, or as is frequently the case, turn to the right or left in a spiral manner, a proper cut should be made. The most simple way for the judge to decide upon the marking for uniformity is to push out all irregular ears and then decide upon the cut to be made from the proportion of uniform to the non-uniform ears.

SCORE CARD FOR CORN AND EXPLANATION OF POINTS

1. Trueness to Type or Breed Characteristics 10
The ten ears of the sample should possess similar or like characteristics and should be true to the variety which they represent.

2. Shape of Ear 10
The shape of the ear should conform to variety type, tapering slightly from butt to tip, but approaching the cylindrical.

3. Color—a. Grain 5
b. Cob 5
The color of the grains should be true to variety and free from mixture, with the exception of a few varieties. White corn should have white cobs, yellow corn red cobs.

4. Market Condition (vitality, maturity, etc.) 10
The ears should be sound, firm, well matured, and free from mold, rot or insect injuries.

5. Tips 5
The tips of the ears should not be too tapering and should be well filled with regular uniform kernels.

6. Butts 5
The rows of kernels should extend in regular order over the butt, leaving a deep depression when the shank is removed. Open and swelled butts are objectionable.

6. Kernels—a. Uniformity of 10
b. Shape of 5
The kernels should be uniform in size, shape and color, and true to the variety type. The kernels should be so shaped that their edges touch from tip to crown. The germ or chit and the tip portions of the kernels are the richest in protein and oil, and hence of the highest feeding value. For this reason the germ should be large and the tip portion should be full and plump.

8. Length of Ear 10
Northern sections 8 1-2 to 9 1-2 inches; central sections 8 3-4 to 9 3-4 inches; southern sections 9 to 10 inches.

9. Circumference of Ear 5
Northern sections 6 1-2 to 7 inches; central sections 6 3-4 to 7 1-4 inches; southern sections 7 to 7 1-2 inches.

10. Space—a. Furrow between rows 5
b. Space between kernels at cob 5
The furrow between the rows of kernels should be small. Space between kernels near the cob is very objectionable.

11. Proportion of corn to cob.................................. 10
The proportion of corn to cob is determined by weight. Depth of kernel, size of the cob and maturity affect the proportion.

Total 100

RULES TO BE USED IN JUDGING

1. Length of Ear—The deficiency and excess in length of all ears not conforming to the standard shall be added together, and for every inch thus obtained, a cut of one point shall be made.

2. Circumference of Ear—The deficiency and excess in circumference of all ears not conforming to the standard shall be added together, and for every two inches thus obtained, a cut of one point shall be made. Measure the circumference at one-third the distance from the butt to the tip of the ear.

3. Proportion of Corn to the Cob—Percent of corn should be from 86 to 87. In determining the proportion of corn to cob weigh and shell every alternate ear in the exhibit. Weigh the cobs and subtract from the weight of the ears, giving the weight of the corn. Divide the weight of the corn by the total weight of ears, which will give the percent of corn. For each percent short of standard a cut of one and one-half points shall be made.

4. In judging corn, a red cob in white corn or a white cob in yellow corn shall be cut at least two points. For one or two mixed kernels a cut of one-fourth point, for four or more mixed kernels, a cut of one-half point shall be made. Kernels missing from the ear shall be counted mixed. Difference in shade or color, as light or dark red, white or cream color, must be scored according to variety characteristics.

5. Exposed Tips—Where the full diameter of the cob is exposed, a cut of one point shall be made and a proportionate cut as the cob is less exposed. Regularity of the rows near the tip, and the size and the shape of the kernels, must also be considered in scoring tips.

6. Scoring Butts—If the kernels are uniform in size and extend over the butt in regular order, give full marking. Small and compressed or enlarged or open butts are objectionable, as are also those with flat, smooth, short kernels, and must be cut according to the judgment of the scorer.

7. Each exhibit should consist of ten ears of corn.

Color—The color should be either a pure yellow with a red cob or a pure white with a white cob. A white cob in a yellow sample or a red cob in a white sample should bar the exhibit. It indicates very poor breeding. In many cases individual kernels are tinted, the yellow with white and the white with yellow color. In this case it shows that a single stray pollen grain has fallen upon a single silk and fertilized the kernel. It is of little detriment to the variety and should be judged accordingly. A rule followed by

many expert judges is to cut one-fourth point for two, one-half point for five, three-fourths point for seven and one point for ten or more mixed kernels. A white ear or cob tinted with yellow or a yellow ear tinted with white must be cut according to the judgment of the scorer.

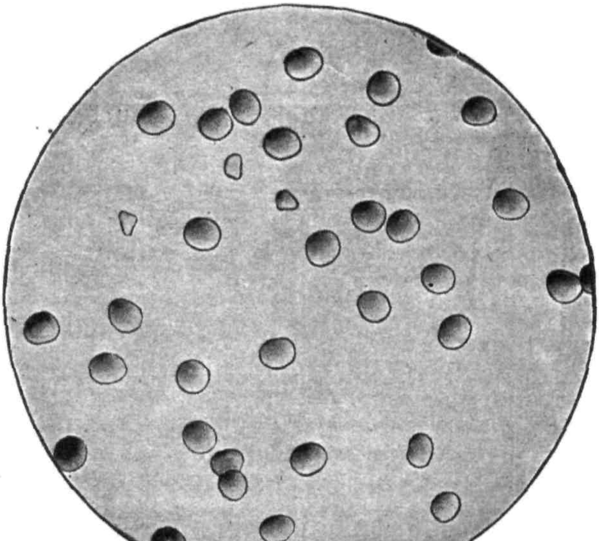


Fig 23—Illustrating Pollen Grains
Magnified. See Chapter IV

Tip—The tips of the ears should not be too tapering and should be well filled with regular, uniform kernels. Where the full diameter of the cob is exposed, a cut of one point should be made and a proportionate cut as the cob is less exposed. Reg-

ularity of the rows near the tip and the shape and size of the kernels must also be considered in scoring tips. The failure of an ear to have the tip well filled may be due to several things, first and most generally to the fact that the silks are not all ready for pollenization during the period when the pollen is ripe. For example, in the case of a very late ear of corn, the tip may not be well filled because the tip silks ripen too late for pollenization. The filling of the tip is also influenced by the season. If the season is unfavorable because of an excessively wet period, during which time the pollen is washed away, or in case of excessively hot winds or a very dry spell during pollenization, the pollen often is destroyed before it has time to completely fertilize the ear. In such seasons and under these circumstances very many ears may be poorly filled. It is desirable that any variety be so bred that all parts of the ear mature in time for the pollen to fully fertilize them. When conditions are favorable doubtless this may be accomplished by the breeder selecting for seed only those ears which are well filled out over the tips.

Butt—In a well-filled butt the kernels should stand out about the shank so that when the ear is broken from the shank a small hollow is left. This assists in securing a large proportion of corn to cob. Not only is this true, but a poorly filled butt is usually accompanied by a large shank. This large, strong shank makes it very difficult for the ear to be broken off during husking, an undesirable quality in any variety. On the other hand, if the butt is very small the shank supporting the ear on the stalk may become so weak that it cannot hold the ear securely and the result will be that the ears will be too easily blown off during windstorms.

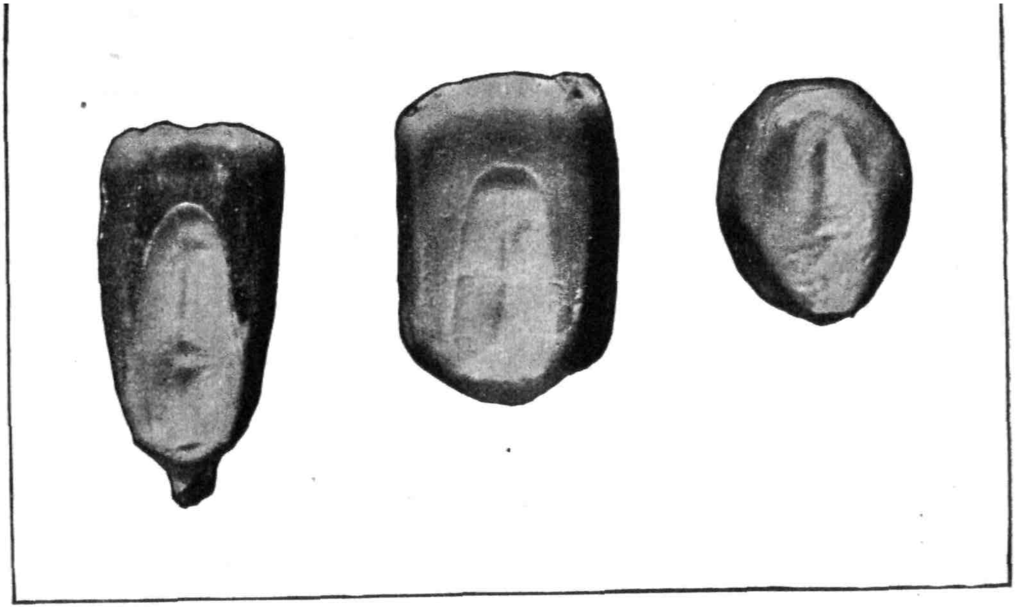


Fig 24—Proper and Improper Shapes of Kernel
At left, kernel proper wedge shape; second, kernel square; third, kernel too nearly round

Circumference—In measuring the circumference of an ear pick up the ear in the left hand, holding the tape line in the right. Press the forefinger of the left hand on the end of the tape and with the right hand bring the tape line around the ear. Keep in mind the deduction in scoring each ear as every ear is measured, and when through measuring subtract the total cut from five, in this way getting the marking for circumference. The circumference is usually measured about one-third the distance from the butt to tip, because this seems to be the most constant point in all ears. If there are any rows dropped or if any other irregularity is present, it usually begins about this point in the ear.

Length—In measuring the length the most simple and satisfactory plan is to hold the rule in both hands so that the left hand near the butt of the ear can guide the measurement. Have a rule or tape at least twelve inches in length, as many ears are that long. By holding the thumb of the right hand at the eleven-inch mark or whatever length is the standard, and running the rule over all the ears, a quick measurement can be made. The judge should keep in mind the number of inches every ear is short of the standard, and by adding these measurements the total deficiency is found.

Ripeness—The ripeness indicating maturity is largely a matter of judgment and no set of rules can be given for the guidance of the judge. Ears that are not sound and dried out; that are not firm, and which, when violently twisted do not give a crisp rasping sound should be given a full cut. An ear on which the rows of kernels are loose, and in which a knife blade can be stuck down between the rows, is immature. Frequently the kernels are very deep and have especially deep indentations. If this be carried

too far, the kernels will not fill out or mature properly and a chaffy ear will result. This condition should be taken into consideration under this head. If there are any rotten or immature kernels in an otherwise fairly well-matured ear a proportional cut should be made.

Kernel Shape—The shape of kernel varies with the different varieties. Every variety has a characteristic shape of kernel, but in general there are certain conditions of shape that all kernels must fill. Such kernels fit around the cob tightly and do not leave a space at the tip near the cob nor a deep furrow between the rows of kernels. If the kernels are square they will angle and a space or furrow between the rows of kernels will result. A broad, square kernel is usually shallow and only a few rows of kernels grow on each cob. This means a small percentage of corn to cob. On the other hand, a well-shaped kernel is usually found on an ear with a large number of rows of kernels and results in a large percentage of corn to cob. The sides of the kernels should be straight. In some varieties the kernels are broad and shallow and there are only a few rows of kernels on the ear. This sort of kernel is the flinty type and is early maturing. In judging the shape it is a good plan to take out two kernels from each ear from about the middle of the ear and lay them out in front of the ear with the tip of the kernel toward the judge. Push out in a separate row the ill-shaped kernels and determine the marking by the proportion of well-shaped kernels.

Kernel Uniformity—The uniformity of kernels can be determined largely by an examination of the ears. The kernels should be of the same size in all parts of the ear with the exception of the egg-shaped rounded tip. The kernels of the different ears should

be of the same size and have the same general character of indentation. The marking on this point is largely a matter of judgment and cannot be guided by any set rule.

Space between rows refers to the furrows formed by the rounding off of the tops of the kernels. It is not, as is generally supposed, the space found on immature ears or ears where the rows of kernels are loose. The ear with space is usually firm and well matured, but the peculiar rounded crown of the kernels causes the furrows. It is indicative of poor breeding, and is usually found in ears having but few rows of kernels. These kernels are usually shallow and broad, and rounded at the corners. Such ears always yield a comparatively small percentage of corn to cob.

Proportion—In determining the proportion of corn to cob, it is the usual custom to select every other ear, making a total of five ears to be weighed. After weighing, shell these ears carefully so as not to break or injure the cob. Then weigh the cobs and subtract this weight from the weight of the five ears; this will give the weight of shelled corn. Divide the weight of shelled corn by the weight of the five ears, which will give the percentage of shelled corn.

Before the individual samples have been shelled, it is advisable to pick out the ten samples scoring the highest, lay them side by side and carefully go over them again in order to get a careful comparative study. This will enable the judge to pick out the best sample with confidence, and is always much safer than to trust to the individual scoring. In fact, it is true that the expert judge soon learns to do away with any hard-and-fast lines in scoring corn.

CHAPTER VI

Preparing the Seedbed

THE conditions of germination are vitality, moisture, heat and oxygen. A judicious handling of the soil in order to supply these conditions is necessary for the best germination of the seed. The yield of the crop depends upon the germination of the seed. By supplying these conditions to vital seed, a complete germination resulting in a perfect stand, will be secured. Further, this vigorous start in the life of the plant, if unchecked by unfavorable circumstances of plant growth, will allow the full and complete development of the plant. Unfavorable conditions, that is, the supplying of the conditions of germination in part, always result in slow growth and a stunted plant.

The kind of preparation for the seedbed will depend upon the nature of the soil. With a clear understanding of the conditions to be secured and the effect of different treatments upon the soil, the kind of preparation is simply a matter of judgment. Under this division of the subject there are a number of particular questions of general importance which will be taken up in their respective order.

Depth of Plowing—The depth to plow varies with the nature of the soil, the season of the year and with the character of previous crop. In general, a coarse, loose, sandy soil should be plowed shallow and a finely divided, heavy clay soil deep. The loose soil needs packing in order to furnish the conditions of germination, while the heavy soil must be opened up to the action of the atmosphere and sun.

The plant food in the soil is liberated for the use by the plants through the agency of soil organisms and chemical action. The organisms require oxygen in their process of development. Therefore the air must circulate freely in the soil in order that these organisms may carry on their work. In the germination of the seed, oxygen is absolutely necessary, so that air must be present for the first process of germination to begin. For instance, it frequently happens that directly after the planting on a clay soil, a heavy dashing rain packs the surface soil so that little air can enter. The seed will germinate very imperfectly even though the other conditions of germination be fully supplied.

It is never advisable, even in the heavy clay soils, to greatly vary the depth of plowing in any one season. If the soil has been turned to a certain depth during its previous cultivation, and then some one season it is plowed several inches deeper than ordinary, a layer of cold soil will be turned up for the young plants to feed upon. If this is done in the fall the action of the weather in freezing and thawing corrects the mechanical condition and puts the plant food in usable form before a crop is grown. However, if this deep plowing is done in the spring, the young plants are unable to use the plant food in this layer of soil and are consequently checked in their growth. This frequently results in an almost complete failure of the crop.

This is illustrated in the history of the cultivation of the sugar beet in Illinois. Before the culture of the crop was thoroughly understood, it was thought necessary to plow very deep in order to furnish a loose seedbed. As a result, most of the fields were plowed several inches deeper than ordinary. The seed was planted in this layer of cold soil and the young plants attempted to secure nourishment from this source. As this soil

was not in condition to furnish the plant food, the beets were stunted and the crops on rich fields were a failure and a loss to the farmers. The next year beets planted on these fields, plowed to the same depth as the previous year, produced paying crops.

As a rule, spring plowing should not be deeper than previous plowings, or if so, the change in depth from year to year should be gradual, not more than an inch or so in any one year. Of course, this practice will vary with the texture of the soil. A lighter soil may be plowed deeper or shallower from year to year than a heavier soil. The time of plowing will determine to a considerable extent the depth. Fall plowing can be deep without danger of injury to the crop. This is particularly true in the colder climates, where the soil is frozen deeply during the winter.

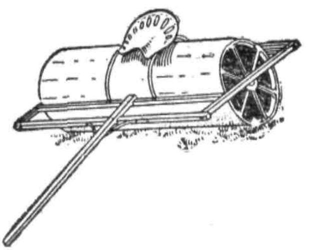


Fig 25—Homemade Land Roller

An effective but simple homemade land roller is here shown. Cover cast-iron mower wheels with 2x4's any suitable length, seven feet a good size. The projections from the surface of the wheels can be first removed with a heavy hammer and cold chisel. Have blacksmith drill the holes, one every four inches on alternate edges of the wheel, for half inch bolts. Bolt the journal boxes under the frame and use set screws in hubs. Make the frame of 4x4 stuff. Cut tenons in end pieces to fit mortises in front and back, and cut mortises in end pieces eight inches from shoulder of tenon for the second front and back pieces. These second pieces make the frame rigid, if properly put together. Notch the tongue one inch where it crosses frames and brace with heavy iron straps. A seat can be attached by bolting on two light wagon wheel rims.

Freezing mellows the soil, and by allowing the air to circulate between the soil particles, the plant food is put in usable form. The practice of deep fall plowing is particularly beneficial upon the heavier soils, as it increases the depth of the seedbed and consequent

amount of plant food available for the growth of the crop. If a heavy crop of stalks or manure is to be turned under it should be done in the fall or early winter and deeply enough to cover the crop completely. If done in the fall the manure or crop of stalks will be decomposed by spring so that a disking will firm the soil, readjust capillarity and put the seedbed in admirable form for plant growth.

FALL OR SPRING PLOWING

Whether to plow in the fall or the spring will depend largely upon: 1, the condition of the soil; 2, the lay of the land; and 3, the kind of previous crop. If the soil is subject to washing and the climate is such that the fields are exposed during a large part of the winter unprotected by snow, fall plowing is apt to be detrimental. If the land is level, and particularly if infested with insect enemies such as the grub worm, corn-root worm, noxious weed seeds, fall plowing is usually very beneficial, if properly handled in the spring. Of course, if a manure crop is grown on the land, or if any trash or straw remains in the soil, it should be plowed under in the late fall.

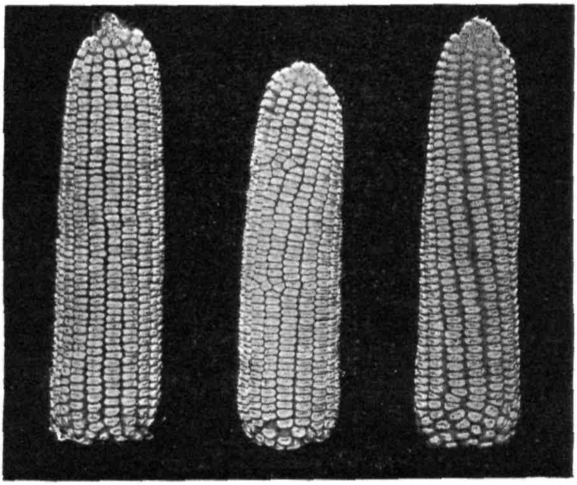
Many of the harmful insects which infest the corn fields live over the winter safely housed in the soil. By fall plowing their homes are broken up, the insect forms are thrown upon the surface of the soil, where they are subject to the winter weather, and most of them are thus destroyed. So in the case of noxious weed seeds which are brought to the surface by fall plowing. The vitality is weakened or lost by the freezing and thawing, and if the vitality is not impaired by such means the weeds are placed where they germinate the first thing in the spring, to be destroyed by the early disking and cultivating of the seedbed.

As the soil organisms which liberate the plant food do not work during the winter in the cold soil, there is probably little plant food lost by evaporation into the atmosphere or leaching through the soil. It has come to be a common practice among the best corn farmers where large areas are cultivated, to fall plow all of the land possible, so that a large amount of land can be quickly planted in spring. In such cases the soil is mellowed through the action of the weather and with a disking, the top and bottom of the seedbed are put into ideal condition for the reception of the seed.

Fitting Spring Plowing for Seedbed—In the case of spring plowing very great progress has been made in the last few years in the methods of handling the soil in order to get the best results. Briefly the most important points are as follows: immediately after plowing the soil should be floated. This should be done at the end of every day's work. A convenient and very successful float can be made by splitting an eight or ten-inch pole twelve feet long. Place the halves two feet apart as split and mortise so that they will be held firmly in place. Arrange a box for weight about the middle of the float and weight as heavily as found desirable. A longer float for two horses can be made in the same manner and the driver can stand on the float. The ordinary plank drags are also used successfully for this purpose. By running the float over the surface of the ground the clods are easily crushed and the top of the seedbed fined so as to make a perfect mulch. This mulch will prevent the excessive evaporation of water and still allow a free circulation of air.

Disking—When the fields of either spring or fall plowing are ready to be planted, disking will loosen and stir the soil, allowing the excess of air to escape, and the seedbed to warm up to the point required for best germination. This point is about 70° F. This

cultivation also firms the bottom of the furrow so that capillarity will furnish the necessary moisture for germination. No more important point in the preparation of the seedbed can be found. In heavy soils with a tendency to lumps, the clods are broken up by the disking and no air space is left to dry out the seedbed and injure the roots of the young corn plants. In loose soil, disking packs the soil, making a more complete and



329 327 328

Fig 26—Direction of Rows of Kernels, Boone County White

No 329, straight rows; 327, rows turn to right; 328, rows turn to left. See Chapter II

successful mulch. By using an ordinary adjustable smoothing harrow after the disk the seedbed is put in the very best condition.

Subsoiling has been recommended by many agricultural writers as a necessary procedure for preparation of the seedbed. A careful distinction must be put

down between trench plowing and subsoiling. Trench plowing is the turning of the bottom of the furrow up on top of the seedbed. This is usually done by a peculiarly constructed plow following in the furrow of the breaking plow.

Subsoiling is the breaking or loosening up of the subsoil without bringing any soil to the surface. This is usually done by a subsoil plow following the furrow of the breaking plow and simply "rooting," or stirring up the subsoil. In the heavier soil it is an advantage. The plate in the bottom of the furrow where the plow pressed and the horses walked year after year, is broken, capillarity re-established and the roots permitted to penetrate the subsoil. The difficulty is the cost of the operation. Even though it be done only once in three or four years, the returns are not enough larger to justify the outlay on corn soils.

It was found that leguminous crops, such as clover, cowpeas and soy beans, rooted deeper in the subsoil. The roots dying and decaying in the soil, allow the air to circulate, permit the action of frost and in fact act as a complete and successful subsoiler. Therefore, owing to the value of these crops as soil fertilizers and as foods, they have come into general use as subsoilers.

Plowing under stalks, straw or manure crops has come to be necessary to the successful culture of corn. In the days of the first cultivation of prairie and other rich soils, the fertility was abundant. Humus was plentiful and it was not necessary to look to the conservation of soil fertility or to the mechanical texture of the soil. As a result of these conditions stalks were burned, and corn grown year after year on the same fields, as the most profitable rotation of crops. This condition does not exist now. Soils that were thought to be inexhaustible in fertility produce less and less,

until the returns are no longer profitable. Hence it has become necessary to consider the waste of soil fertility in corn culture and to conserve this plant food carefully for future crops.

A large amount of fertility is lost through burning stalks and straw. The important element in this material for plant food, nitrogen, is lost in burning. The other two valuable elements, phosphorus and potash, are left in such shape that they are easily washed away, dissipated and lost. The remedy for this condition is to plow under all stalks and straw. In the case of cornstalks, where they have been pastured off during the winter, they can be easily harrowed down and plowed under. This can be accomplished successfully by hitching one horse to a section of a harrow behind the plow. If the stalks are very heavy, they can be cut with stalk cutters, the plow provided with a rolling coulter or jointer and the rows of stalks easily turned under. Another successful plan is to disk the field of cornstalks. This plan will cut up the stalks and permit their being plowed under successfully.

In plowing under fertilizing crops which have been sowed in the corn at the time of the last cultivation, such as cowpeas or soy beans, or have been sowed after oats have been harvested, it is desirable to do this as early in the fall as possible. The longer they have been turned under previous to freezing weather, the more complete the decomposition and decay by the time the crop needs the fertility. One advantage of such a fertilizing crop is that after the corn has ceased growing or after the oats have been harvested, the soil fertility is being continually liberated by the action of the soil organisms during warm weather. These crops coming on at this time take up this fertility, which might otherwise be dissipated into the atmosphere or leached out by rains. They hold it until they are

plowed under, when through decomposition they give it up for the use of the succeeding crops. In the case of leguminous manure crops, there is a valuable addition of nitrogen to the soil directly through the action of the organisms forming the tubercles on the roots of such plants.

Time of Plowing—One of the points in the preparation of the seedbed above all others is to plow the ground when it is in proper condition. If a heavy soil and too wet, it runs together, and when the seedbed dries out and bakes, is injurious to the roots of the corn plant, and will not retain soil moisture. The more finely divided the soil the more moisture it is capable of conserving. If the seedbed is caked by wet plowing, only a small amount of the plant food can be used by the plants, and not enough moisture will be retained for the growth of the crop. As a result, when the soil is too dry and breaks up in clods and large lumps, a great amount of preparation is needed to get such a field into condition for planting and by the time such cultivation is finished the tilth of the seedbed will have been destroyed. There is usually a time in every season when plowing will leave the field in splendid condition, and it is important to wait until that time, as it always results in a saving of time and money and a better prepared seedbed.

CHAPTER VII

Feeding the Plant

THE corn crop thrives well on a wide variety of soils, ranging from a light sand to a heavy clay. A typical soil for the crop may be described as a medium loam, well supplied with vegetable matter, and overlying a subsoil of good texture. The chief needs for the crop are an abundance of moisture and of available plant food during the season of its growth. The fact that the average yield for the United States is reported as only about twenty-five bushels per acre, shows that notwithstanding the very high yields that are obtained under perfect conditions, there is a large area grown under conditions which are so imperfect as to result in a small and generally unprofitable yield, and in many cases, particularly in the eastern and southern states, this is due to a lack of available food during the season of growth. This need of food is due to two causes, first, the impoverished character of the soil, both natural and artificial, the latter due to long years of cropping, without adequate return of manure; and second, to improper methods of management. That a large crop cannot be grown on a very poor soil is clearly indicated by the composition of the plant. A crop of fifty bushels of shelled corn per acre, with the accompanying stalks, will remove from the soil, on the average: Nitrogen, eighty pounds; phosphoric acid, twenty-nine pounds; potash, fifty-five pounds.

From the standpoint of the removal of the fertility elements, therefore, it is an exhaustive crop; nevertheless, because of the period of growth, and because of

its ameliorating and renovating character, its growth really results in reducing immediate fertility much less than would a crop containing the same amount of constituents grown at a different season and without cultivation. Still, in order that the food required by a crop of this size may be obtained, it is essential that on land of good natural fertility, it shall be well prepared and managed, and that poorer soils shall receive a judicious application of manures.

THE NATURAL CHARACTER OF SOIL A GUIDE AS TO THE NEEDS OF THE PLANT

The natural character of the soil is a guide to some extent in determining whether the crop can be successfully grown without added fertility. A large crop cannot be expected on a light, sandy soil, naturally deficient in potash, unless that particular element is applied, because the analysis of the crop shows that this constituent is required in relatively large amounts. The same is true of nitrogen; a sandy soil is naturally deficient in this element, and a large crop could not be expected without the direct addition of fertilizers containing nitrogen, or the introduction of this element indirectly in the form of green manures from leguminous crops. Still a good corn crop can be grown on such soils with a smaller quantity of both nitrogen and potash than could a crop of a different class, which makes its maximum growth at a different season.

Corn Plant a Good Forager—The corn crop is, in the first place, a good forager, due to the vigor of the crop itself, extracting food unavailable to less vigorous growers; in the second place, it has an advantage over many cereal crops in the season of its growth, namely, the summer, when the natural agencies, sun, air and water, are most active in causing insoluble materials

to become more rapidly available; and in the third place, the cultivation assists materially in unlocking and providing food otherwise unavailable.

It must be remembered, too, that owing to the widely varying conditions of soil and climate in those states in which corn can be grown, the requirements in reference to manures may also vary widely even on the same character of soil. In the more northern sections, where the season is short, a relatively greater abundance of available food in the soil is required than would be the case in the more southern sections, where the season of growth is much longer, or in the middle western sections, where the period of hot, bright, growing weather is longer.

MANURES AND FERTILIZERS: THEIR CHARACTER AND FUNCTIONS

With these general considerations concerning the crop, and its characteristics, arises the special question of its feeding, and, in order that a proper understanding of the subject may be obtained, it is necessary to discuss the question of manures and their functions in some detail.

What Is a Manure?—In the first place, a manure in the broad sense may be regarded as a substance that will cause an increase in crop. Still, this is indefinite. The idea that should be conveyed by the term "manure" is that it shall contain those constituents that are liable to exist in soils in minimum amounts, and which are carried away in maximum amounts by the crops removed. These essential constituents are usually limited to three, namely, nitrogen, phosphoric acid and potash. The term "essential" does not mean that they are more essential to the growth of the plant than others required by it, like lime, iron, sulphur, etc, but

that they are more essential than the others in manures, which are usually present in great abundance in most soils, and their addition would not contribute to actual fertility.

In the second place, certain substances containing these constituents have both a direct and indirect fertilizing effect, that is, they add to the constituents in the soil, as well as change and make available the otherwise unavailable constituents already in the soil, while others are only direct in their effect, and still others indirect. The natural products, as farm manures and wastes of various sources, belong to the first class, namely, those which possess a direct and an indirect value.

This indirect effect is often of great service, chiefly in changing the physical character of the soil in such a way as to enable the natural agencies to act more effectively. As, for example, on a heavy, compact soil, which does not freely permit the entrance of air and moisture, the addition of the vegetable matter contained in farm manure would have the effect of opening up and separating the particles, thus making the soil more porous and permitting the free access of air and water, and consequently greater and more rapid changes, which contribute indirectly to an increase in crop. On a sandy soil, on the other hand, the addition of manures of this character would also improve because making the soil less open and porous, drawing the particles of soil together and making it more compact, thus preventing the rapid drying out of the soil, and the rapid leaching from it of the soluble constituents.

Direct Manures—To the second class, or to the direct manures, belong the artificial products, which are valuable chiefly because they contain the constituent elements, nitrogen, phosphoric acid and potash, which contribute directly to the potential fertility of the soil,

or, in other words, these products contain those constituents which are likely to be deficient, and are valuable mainly for this reason.

In the third place, it must be remembered that manures, both direct and indirect, differ in respect to the character of the constituents that are contained in them. The plant can obtain its food only in a soluble form, and all materials containing plant food in an insoluble form must change to the soluble state, and the different materials containing these constituents differ widely in the rate at which they change from an insoluble form to a soluble and available one, even when used under the same conditions of soil and climate. Those materials containing constituents that are soluble are in most cases called immediately available, and those containing them in an insoluble state vary in their value according to the rate at which they will change from an insoluble to a soluble form under the average conditions of soil, season and climate.

In the farm manures, for example, the solid portion contains the chief constituents, nitrogen, phosphoric acid, in an insoluble form, while the liquid portion contains them in a more soluble state, and experiments have demonstrated that the nitrogen, particularly in the liquid portion, is more easily obtained by the plants than that in the solid. Of the same amount of nitrogen in the solid and the solid and liquid portions combined, the immediate crop will use three times as much of the latter as of the former. It is, therefore, not altogether a question of manure, but of the quality of the constituents contained in it. The same principle is true in regard to the nitrogen in the different artificial products—there is a wide range of availability. Nitrate of soda contains it in its most soluble and available form, and the returns from a unit of nitrate nitro-

gen, other things being equal, will generally be greater than from other forms.

These considerations apply to all of the constituents, though more particularly to nitrogen and phosphoric acid. The insoluble form of phosphoric acid, for example, must change to the "reverted," or soluble form, before the plant can use it; great care should, therefore, be exercised in the use of the insoluble. That form which will be most likely to change quickly should be selected, though there are conditions where insoluble forms are quite as useful as those more quickly available, owing to the differences that occur in soils and crops and in their periods of growth.

WHAT SHALL BE USED

Naturally, the first question the thoughtful man asks is, "What shall I apply, nitrogen, phosphoric acid or potash, or all, and in what form?" The question cannot be answered in a categorical way. The answer will depend upon the conditions that exist. In many instances one element only may be deficient in the soil; in others two, and in still others all three may be required. Positive and helpful information on these points cannot be obtained except by actual experiment. Still, much very useful information may be given the practical man who is unable to make these experiments for himself, and it is based upon a knowledge of the original character of the soil, the kind of cropping that has been practiced, the rotation, and the methods of management adopted.

As already indicated, soils differ widely in their composition. The poorest are those made up chiefly of sand, which can, from the nature of the substances composing it, contain but small quantities of plant food; the best, those which are admixtures of sand,

clay, lime and vegetable matter, and which contain in themselves naturally such an abundance of plant food as to supply the needs of plants for very long periods. As a broad general rule, therefore, sandy soils are deficient in practically all of the constituent elements, while peaty soils are deficient in the mineral elements. The various clay soils are usually rich in potash, shale and limestone soils are rich in lime and phosphoric acid, and alluvial soils rich in all the plant food elements.

Guides in Use of Plant Food—The previous cropping also is a reasonable guide as to the probable necessities of the plant. If, for example, wheat or corn or hay, or any one crop has been grown continuously for a long time, and no manure has been returned, then the chances are that in order to continue their growth on soils not naturally very rich, all of the constituents will be required, as the crop will remove the same constituents in the same proportion year after year, thus reducing very rapidly the store of active fertility. If, on the other hand, crops have been grown in rotation which take from the soil the constituents in different amounts and proportions, and also introduce by their roots and stubble considerable vegetable matter, the apparent exhaustion will be extended, and the application of one or two of the constituents will meet the needs.

In the next place, the character of the crop, and the period in which it makes its most rapid growth, will guide as to the application required. If the period of growth is short, a greater abundance of available food will be required than if the growth extends through a long period. The food requirements for particular seasons are also important if the maximum growth is in the very early season, as April and May, as is the case with wheat, and the grasses—a larger amount of nitrogen will be required than for a crop

which makes its most rapid growth during the summer season, June, July and August. The conditions are not favorable in the early spring months for the change of organic nitrogenous matter in the soil into nitrates, whereas during the hot summer months the conditions are extremely favorable for the change.

Hence, upon soils containing a reasonable amount of vegetable matter, the application of nitrogen to wheat and grass might result in a very large increase, whereas its application to a corn crop might not be

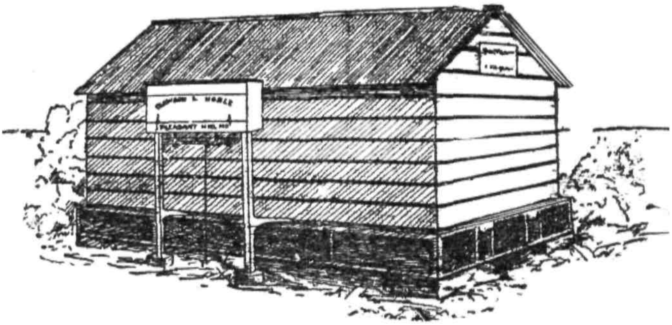


Fig 27—Corn Crib on Scales

At Iowa experiment station

followed by a considerable increase, because in the first case the conditions make it needful that the crop shall have an abundance of nitrogen, and in the second case the conditions favor the change of the nitrogen already in the soil into an available form. So it is that on the same soil, one crop might be benefited by the application of nitrogen, while for another the application of nitrogen would not be likely to cause a profitable increase in yield. The crop grown, too, and its period of growth, determine to some extent the form, as well as the kind, of element that should be applied.

In the case of wheat and grass, an application of organic nitrogen in slowly available forms would not result in an increase in crop, because the conditions that are not favorable to the change of the nitrogenous material in the soil would apply just the same to those applied, and the result would be that the plant could not obtain it. Hence for those crops the nitrogen should be in a soluble and active form, so that it may be readily distributed and that the crop may obtain it at once. Whereas, in the case of corn grown upon land deficient in nitrogen, organic forms, which are likely to change rapidly, owing to the favorable conditions, would be likely to be quite as useful as the soluble and immediately available forms, because these might be carried away from the plant by the rains that are usually abundant during this season.

From these considerations, it will be observed that no positive and definite rules can be given as to the kind and amount of application, but only broad, general rules, which must be interpreted by the farmer himself for his peculiar conditions.

RESULTS OF EXPERIMENTS

The experiment stations of the country, particularly those of the eastern and southern states, have carried out experiments to determine the fertility needs of different soils and crops. Widely varying results have been obtained, chiefly for the reasons already outlined. In a broad general way, the results in the eastern states show that of the minerals, potash seems to be needed especially for corn, while in the southern states phosphoric acid is the chief constituent lacking, though upon lands naturally poor, the addition of all of the constituents is required, if maximum crops are obtained.

Still, the results, broadly interpreted, show that with the exception of limited areas of special character, the lands of the east and south, which have been cultivated for a long time, are benefited by the addition of fertilizers, and in most instances all the constituents are required. This is a safe assumption, where no specific information derived from experiments is available, because we have not yet attained maximum yields

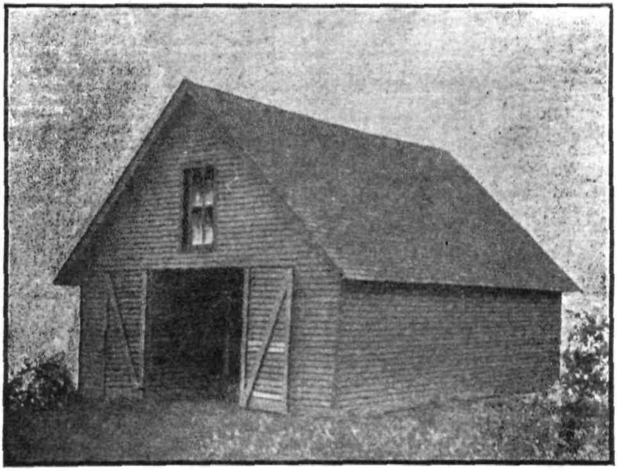


Fig 28—Modern Corn Crib
At Minnesota experiment station

in these states under natural conditions. The experiments also show that it is a question of applied plant food, not only, but also of its systematic and intelligent use. The "hit or miss" system in the application of fertilizers or manures is not a good one.

Classification of Crops—It has also been clearly demonstrated, in addition, that there is a proper relation between the cost of the material applied and the

value of the crop obtained, which must be observed in the profitable use of materials. Crops are, in respect to fertilizers, divided into two general classes, first, those which possess a high fertility value and a low commercial value, and second, those which possess a low fertility value and a high commercial value.

To the first class belong the cereals and to the second class vegetables and fruit crops, hence in the application of manures or fertilizers to the first class, greater care must be exercised in order to obtain a profit, because the financial return per unit of application is much less in the first than in the second class. That it can be done profitably has been shown by many experiments and by practice, provided all the considerations underlying are carefully observed, for, as already pointed out, crops differ in respect to their need of added food, due both to their specific requirements and their period of growth. Hence in a rotation of crops the application may be adjusted in such a way as to reduce the cost of application to a minimum, while at the same time encouraging a maximum growth.

In any rotation of the first class of crops which may be adopted, whether (1) corn, (2) corn, barley, wheat and hay, (3) corn, beans, wheat and hay, oats, wheat and hay, (4) corn, wheat or rye and hay, (5) corn and cotton, (6) tobacco and cotton, or others which are used, a careful observation of the principle that different crops require different kinds and proportions of food, because of differences in their power of acquiring food, and their season of growth, should result in the application of those constituents that are specifically needed for the particular crop, which will contribute to its increase and leave a residue for the succeeding crop. By this method there would result from a systematic application of manures and ferti-

lizers, in a rotation, a profitable increase in crop, and a constant increase in "condition" of soil.

FERTILIZERS FOR FIELD CORN

In view of the character of the crop, and the season of its growth, there is no cereal crop which will utilize to better advantage the coarser yard manure of the farm. The crop is a gross feeder, besides the season of growth and cultivation are favorable for the decomposition of the manure. Too many farmers allow the manure made in winter to lie in the open yard until fall for application to wheat, thus losing much of its value, besides getting no return from it until the next season, when the wheat is sold. It is a good practice for the eastern and middle states, therefore, to apply manure broadcast in the late fall, winter or early spring, at the rate of from six to eight tons per acre; by this method the soluble portions are well distributed and are absorbed by the soil before plowing.

If the corn is planted on sod land, then the nitrogen contained in the manure and in the organic matter in the roots and stubble should be sufficient upon ordinarily good land to supply all the needed requirements for this element. If the land has been heavily cropped, or the purpose is, as it should be, to obtain a maximum yield, then the possible deficiency of minerals in the manures should be made good by an application of two hundred and fifty pounds per acre of a mixture made up of:

MIXTURE NO I

Ground bone	250 pounds
Acid phosphate	500 pounds
Muriate of potash	250 pounds

In this mixture a part of the phosphoric acid is in a soluble form, and will supply the early needs of

the crop; the remainder is in the form of ground bone, which will decay rapidly enough to supply the demands of the latter growth, and the portion not used will contribute to the potential fertility. The potash may be in the form of muriate, as it is distributed readily, is cheap, and does not contain substances which would make it unsafe to apply in the drill in the quantities here given, and may, therefore, be added in the row with the planter, though on heavy lands the minerals would better be applied broadcast and harrowed in, since the use of muriate of potash results in a loss of lime; if it is continued, the land should be limed at the rate of twenty-five bushels per acre, once in five or eight years, on the sod the year previous to planting. Lime is also useful in aiding in the decomposition of vegetable matter, in setting free phosphoric acid and potash, and in neutralizing any acidity of soil.

The constituents furnished by the manure and the mixture are sufficient for a good crop, without dependence upon soil supplies, if all could be obtained, but this is not usually the case, because absolutely perfect distribution cannot be expected, and besides conditions of season are not always so perfect as to permit a continuous feeding throughout the entire growing season. In an average season, however, a large increase in yield should be obtained, and a considerable residue of fertility left for subsequent crops. On light, sandy soils, the mixture should also contain nitrogen in addition to that added in the manures, both to give the plant an early start and to aid in the feeding throughout the season. A brand well adapted for supplementing yard manure on sandy soils may contain ammonia two per cent, available phosphoric acid eight per cent, and potash ten per cent, and which may be made up of:

MIXTURE NO 2

Cottonseed meal, or dried ground fish	200 pounds
Acid phosphate	600 pounds
Muriate of potash	200 pounds

An application of from three hundred to five hundred pounds per acre of this mixture would be sufficient under average conditions. In the more northern regions, where the season is shorter, larger applications, and in the more southern sections, where the season is longer, small quantities of the fertilizer mixture would answer where the physical conditions of soil are good.

It must be remembered that the better the physical and mechanical character of the soil, the greater will be the absorption by the plant per unit of food applied. That is, a better distribution of the fertilizer would occur, and the agencies which assist in solution would on such soils have a better opportunity for action.

Moderate Quantities Often Sufficient—Large quantities of fertilizer are not recommended for corn under average conditions; an application of a medium amount would be more likely to result in a profit. Where farm manure is not available, and entire dependence is placed upon purchased supplies, or where raw ground instead of sod is used, mixtures containing larger proportions of nitrogen and heavier applications are required. A brand containing nitrogen four per cent, phosphoric acid (available) eight per cent, and potash eight per cent, applied at the rate of five hundred pounds per acre, should supply the needed constituents in good forms and proportions. Part of this application may be made broadcast and harrowed in, the remainder, say one-half, applied in the drill at time of planting.

It is a good plan to apply the materials broadcast wherever possible, and in lieu of the recommendations made, three hundred and fifty pounds per acre of mix-

ture No 1 may be used, applied broadcast, in connection with a compost, applied in the hill. This would be particularly advantageous on heavy, clayey soils, as it is desirable there to have minerals well distributed and to encourage the early growth of the corn by substances rich in organic matter, applied in the hill. This compost may be made up largely of fine cow or horse manure, fortified by the addition of ground fish, dried blood or cottonseed meal. The addition of three hundred pounds of dried blood, or five hundred pounds of ground fish or cottonseed meal, to a ton of dry composted manure, would be excellent for this purpose, and make a relatively cheap compost.

In the southern states, there is probably no better and cheaper, and, therefore, no more satisfactory form of organic nitrogen, all things considered, than cottonseed meal, and in Georgia particularly, where a careful study of the matter has been made, the following formula is recommended for well improved upland soil, or bottom lands:

Cottonseed meal	870 pounds
Acid phosphate	1000 pounds
Muriate of potash	30 pounds

and for wornout upland soils:

Cottonseed meal	1000 pounds
Acid phosphate	1250 pounds
Muriate of potash	30 pounds

The chief need of these soils is for nitrogen and phosphoric acid, and an application of from two hundred and fifty to four hundred pounds per acre has been found the most economical. These recommendations will probably apply to the upland and bottom lands of the southern coast states, whereas for the sandy lands, a larger proportion of potash is needed; in Kentucky and Tennessee, potash has been shown to be a very important ingredient in fertilizers for corn.

FOR FORAGE AND SILAGE CORN

In the growing of field corn, the main object is to obtain the greatest yield of grain, whereas in the case of forage, when used green or for silage, a larger proportion of stalk and leaf is desirable; besides it is advisable when possible to obtain a food richer in protein, and a thicker planting and an abundance of nitrogen in the manures contribute to this end. Hence, while the recommendations already made for field corn may be followed in respect to the kind of materials for silage corn, larger applications are desirable. On good soils apply ten tons of good manure to supply the organic nitrogen and part of the mineral constituents, and from three hundred to four hundred pounds of mixture No 1.

Briefly stated, then, for silage corn, apply broadcast previous to plowing, ten to twelve tons of good yard manure, and either broadcast or in the row at time of planting, three hundred and fifty to four hundred pounds of mixture No 1. On poor soils, the manure need not be increased, but the amount of fertilizer added and the proportion of nitrogen should be. The same recommendations that are made for different localities may be followed, as in the case of field corn.

Where a leguminous crop like crimson clover is used as a catch crop, a continuous growing of corn is entirely practicable, though the fertilization should be very different from that recommended when either a sod land or raw ground is used. This system is well adapted for the middle and northermost of the gulf states. For the more southern and central states, and those of the middle west, such crops as cowpeas or soy beans may be grown to much better advantage as green manure. In any case, whatever crop is grown, provided it is a leguminous crop, the practice in reference

to fertilizers should not be far different, and should consist mainly of the applications of the minerals, the nitrogen gathered by the legumes furnishing vegetable matter containing nitrogen, which would be readily acquired by the corn plant.

A practice that has given very excellent satisfaction upon naturally good soils in the middle states is as follows: Seed the crimson clover in the corn usually in July, at the last cultivation, plow in spring, when the clover is beginning to head, or before it has made its maximum growth, in order that all of the crop may be turned under before it has absorbed too much of the surface moisture. Roll immediately, in order to compact the soil, and thoroughly and deeply cultivate the surface, and at time of planting apply two hundred and fifty pounds per acre of a mixture made up of:

Acid phosphate	150 pounds
Muriate of potash	50 pounds

Where the soils are poorer, or where the physical condition is not good, then a larger application of the minerals should be made, preferably broadcast and harrowed in. The application then may consist of four hundred pounds per acre of the mixture recommended. On very poor soils, where the leguminous crop does not grow vigorously, a larger application of this mixture may be made, say five hundred pounds per acre, and at planting, accompanied by the top-dressing of compost, already suggested. This practice may be continued from year to year, and should result in continuously increasing the fertility of the soil, as the minerals applied and the nitrogen gathered would be more than sufficient to supply the needs of a large crop.

The one element of danger in the use of green manures, particularly crimson clover, is that the farmer

will not plow down early enough, and should hot, dry weather follow, the young corn plant will not be able to obtain sufficient moisture; the mass of organic vegetable matter plowed down prevents the water connection between the surface and subsoil, the surface thus becomes so dry as to injure the crop. Should the weather be very warm and moist, then the very rapid fermentation of so large a mass of vegetable matter may also be injurious.

In any case, or all cases, however, injury of this character may be obviated by the occasional dressing with lime, and where considerable amounts of vegetable matter are added, either directly as farm manure, or indirectly, as green manure, it is a very desirable practice, as already pointed out, to lime at least once in five or eight years, at the rate of twenty to twenty-five bushels per acre; the lime neutralizing the acidity developed by the too rapid fermentation of the vegetable matter, besides encouraging the development and growth of bacteria, whose influence in improving soil conditions is very marked. In case of crops like cowpeas, which make their growth in the season preceding the planting, injury to soil is not to be feared.

MANURES FOR SWEET CORN

The growing of sweet corn for the market is a very considerable industry in many states, and its proper fertilization is an important matter. The most profitable crops, as a rule, are those that are grown early. Hence, the fertilization should be such as to encourage a very rapid early growth. That is, corn should be ready for market from a month to six weeks earlier than is the case where planted at the usual time, and grown under ordinary conditions. It is necessary, therefore, that the plant should have an abundance, not only

of all food constituents, but that they shall be of a highly available character.

The mineral elements may be derived from the same source as those recommended for field and forage corn. The nitrogen should be obtained from quick-acting materials, and preferably in organic forms, though part may be obtained from nitrate of soda. An application of five hundred to eight hundred pounds per acre of a mixture showing: nitrogen four per cent, phosphoric acid (available) six per cent, and potash eight per cent would furnish on most soils suitable for the crop a sufficient abundance of the constituents. For the central and eastern conditions of climate, one-third at least of the nitrogen may be in the form of nitrate of soda or sulphate of ammonia, the remainder in organic forms, as dried blood, dried fish, cottonseed meal, etc; for the southern conditions, all of the nitrogen may be derived from cottonseed meal, though where this material is the entire source of nitrogen, a larger application should be made. Sweet corn may be regarded as a crop belonging to the second class, or possessing a high commercial value, and, therefore, much larger applications can be afforded than in the case of the field corn.

In all of these recommendations care has been exercised in the suggestions to keep well within practical limits. The principles are well defined; it rests with the farmer intelligently to apply them to his conditions. Corn growing can be made profitable by the judicious use of fertilizers, in a reasonable rotation, and in connection with the proper saving and using of manures.

CHAPTER VIII

Planting and Cultivating

THE time for planting corn is after the seedbed has been so prepared as to furnish the conditions of germination, and danger from frost is passed. There is a decided loss to the grower by planting corn under unfavorable conditions or by having it cut down by frost. If cut off by frost the seed will regerminate, but the plant will never recover its vigor and vitality. Regermination always results in a lessened yield.

Late Planting—If planted too late the plant does not have time enough during the growing season to mature. Absolute rules for the time of planting for all sections of the country are obviously impossible. However, there is a time every season which is favorable for planting. It is the business of the farmer to have the seedbed prepared in order to take advantage of this propitious time.

The depth of planting varies with the kind of soil. In general corn should be planted deeper in light, loose, sandy soils than in heavy clay soils. This rule holds true, because in order to furnish the required amount of moisture for germination it is necessary to go deeper in loose soils than in the heavier clay soils. Further, it is easier for the plumule to reach the surface in loose than in heavy soils, as the young plant cannot secure any plant food from the air or soil until the leaves reach the surface.

It is necessary to plant shallow so that the seed will furnish enough plant food to supply the young plants until the leaves reach the atmosphere and the

plant can begin to use the food in the soil and in the air. The loose, sandy soils warm up more quickly than the heavier clays, so that in order to get the necessary heat for the best germination the depth of planting must be regulated by the character of the soil. In the loose prairie loams of Illinois, Iowa and Nebraska the state experiment stations find that two to four inches will give the best results. This depth will vary with the season and the time in the season of planting.

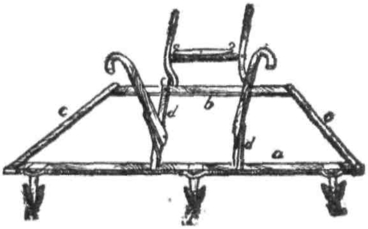


Fig 29—Effective Corn Marker for Hand Planting

A few farmers still prefer to plant corn by hand, and for these the marker here shown will prove helpful. The materials needed are one piece of wood, *a*, 2x4, about nine feet long, one piece, *b*, 2x4, about four feet long, two pieces, *d d*, each two feet long, and two pieces of scantling, *c c*, about four feet long, two old plow handles, an old pair of buggy shafts, and three or four old cultivator shovels. Set the shovels the proper distance apart to make rows as required.

In an early season, or if the planting is done late in the season, after the soil has been thoroughly warmed, the corn can be planted deeper than during a late season or early in the season before the soil warms up. The depth will also vary somewhat with the size of seed. If the seed is small, it should be planted shallower than larger seed. Where small seed has been planted deep in the prairie loam soils, only a small proportion of the plants reached the surface, while large seed planted at the same depths all came up.

The depth of planting must vary with the amount of moisture in the soil. If the soil is very moist at the time of planting, the seed should be planted more shallow than if the soil is comparatively dry. This is true

from the fact that it is necessary to go deeper in a dry soil in order to secure the moisture for germination, and because the dry soils warm up more quickly than the moist soils. Seed planted deep in dry soils obtain enough heat for germination. It has recently been discovered that no matter how deep seeds may be planted, the root system develops always at about the same depth. That is, the seed planted deep in the soil sends up a tube to the ordinary point at which the roots develop. At the end of this tube the permanent roots branch out and a stem is sent up into the atmosphere. See Fig 32.

HILLING OR DRILLING

The practice of hilling or drilling corn will depend upon the fertility of the soil, the condition of the field, the amount of weeds or weed seeds in the soil, and the variety of corn. As a rule it is not advisable to plant more than four stalks in a hill, because they will interfere with each other in plant growth. So then if in a very fertile soil it is desirable to plant more kernels than this per hill, it is the best practice to plant in drills.

However, if the field is very weedy it is not desirable to plant in drills, because the drilled corn cannot be cross-cultivated and the field is likely to grow to weeds. If a small variety of corn, more kernels can be grown in a hill than a large variety. This is particularly true if the large variety has a correspondingly large amount of foliage. The large plants growing in a hill will naturally shade the other plants and interfere in their development. On soils that have been plowed for the first time, it is sometimes desirable to drill the corn. Such fields are usually comparatively free from the noxious weeds which seem to follow continued cultivation. They are usually very fertile and able to

support more plants than can be grown in hills. In this case it is good practice to drill in order to use up the fertility of the soil which might otherwise be lost in the atmosphere or through leaching. When corn is grown for a soiling or forage crop drilling is desirable. In this case ears are not sought, but the object is to secure the largest possible amount of foliage. This can be done by drilling the seed closely in the rows.

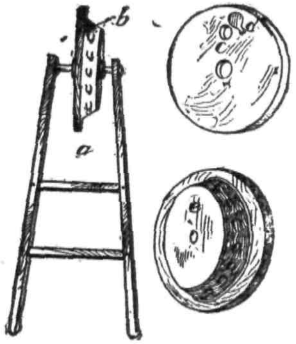


Fig 30—Homemade Corn Planter

A very satisfactory corn planter is here shown. Make a frame, *a*, like a wheelbarrow frame and three inches longer than the pan used. Take a tin pan and put on the axle of the wheelbarrow against the wheel *b*. The hole in the center of the pan must be in the center and must fit the axle. Put into the flaring side of the pan inch openings the shape of the end of your thumb, only do not remove the piece of tin. Leave one side hanging so that you can spring it open or push it shut, to regulate the dropping of the corn. Make these openings three or four inches apart, then open them or shut them, according as you want the corn dropped. By wheeling this barrow along in your marked field it can be easily adjusted to drop as many kernels as desired. The pan is filled through a two-inch hole, *c*, in the board wheel. This is subsequently closed with a swing slide, *d*. The corn may be covered with a harrow across the rows or other suitable implement.

LISTING CORN

This method is followed with success in some of the western states, as Kansas, Nebraska and Minnesota. In this case the soil is a loose, sandy loam, which dries out early in the spring and the water percolates through it quickly after a rainfall. In many cases where listing is followed successfully, there is a scarcity of moisture in the soil for germination. Therefore it is necessary to get the seed down in the soil in order to secure enough moisture for proper germination. The general

practice in listing is to go into the unprepared field with a specially constructed machine called a lister. This lister is arranged like a double plow, so that it throws out a furrow. The corn is drilled in the bottom of this furrow, and loose dirt is dragged over the seed by small hooks which catch the earth on the sides of the furrows. The rows are usually drilled about three and one-half feet apart, and when cultivated, the dirt is rolled down into the furrow until at the end of the season the field is level.

Listing in Eastern States—Owing to the success of this practice in the western states, it has been introduced into Illinois and some of the eastern states. In these cases it has not been entirely successful. The method of listing has been changed to suit the eastern conditions. Instead of going into the unprepared field and listing the corn, most farmers furrow out the field late in the fall or during the winter. These furrows are drawn about three and one-half feet apart, so there is a ridge of loose dirt between the two furrows. At the time of planting these ridges are split with the lister and the old furrows filled up. In this way the surplus water is allowed to drain out of the soil and the seedbed is put in condition for germination. After the second set of furrows has been made the seed is planted with an ordinary corn planter, the runners of the planter following in the furrows made by the lister. Usually the seed is checked, thus allowing cross-cultivation.

The objection to listing, as ordinarily practiced, in the eastern states, or in the heavier loam soils, is that the seed is put down in a dead furrow where it is too cold for germination. There is no reason, in such soils, for going down to secure moisture, because there is usually an excess of water for germination. After the corn comes up it is not possible to stir the soil about

the young plants and cut out the small weeds. They cannot be covered up and killed with loose dirt, and the consequence is that the corn is injured by weeds and the weed roots are allowed to mature and seed the field.

Where the listed corn is checked, this disadvantage is partly done away with, and the field corn can be more perfectly cleaned. In the loose, sandy soils listing might be an advantage. The seed is put down deep enough to secure plenty of moisture for germination and the soil is usually warmed up as deep as the seed is planted. It is further claimed than a deeper root development is a result of listing and that listed corn will withstand the storms of summer better than corn not listed.

At the Illinois station, extensive series of experiments with listing compared to ordinary culture showed there was little difference between the listed corn and the corn planted in the ordinary manner. In fact, observations on this point in different sections of the state showed that corn planted in the ordinary manner seemed to stand up better than the listed corn. The results of the experiments at this station showed a uniformly larger yield from the corn planted with the ordinary planter than the listed corn. The soil in the listed fields was left in poor condition to stand the rains of winter, and was exceedingly difficult to plow in the spring. A large crop of weeds was grown in the field, even with the most careful and frequent cultivation. In the western states, where the fields have not become seeded to noxious weeds as yet, and with their peculiar conditions, listing may be an economical and satisfactory method of planting corn.

Number of Stalks per Hill—The number of stalks to plant in the hill will vary with the variety of corn and with the character of the soil. With a large variety of improved corn, a few stalks in the hill will give

better results than a large number. With ordinary field seed, experiments made by the Illinois station show that a larger number of stalks will give the best result on the rich prairie soils.

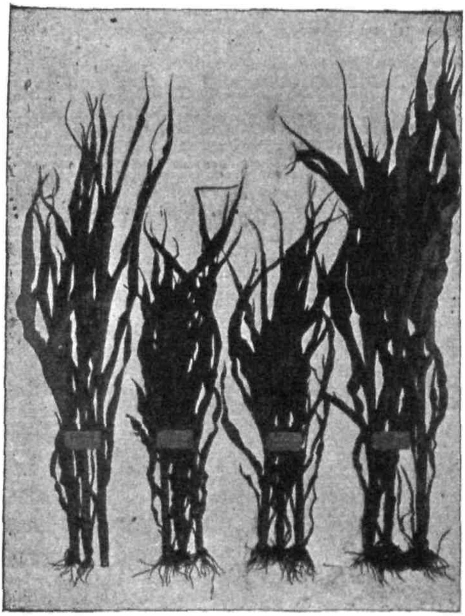


Fig 31—Effects of Listing

The stalks on extreme left planted in ordinary way. Second, listed on prepared ground. Third, listed on unprepared ground. Fourth, ridged

If the corn is planted the ordinary distance apart, three and two-thirds feet, and one stalk is grown in every hill, and every stalk produce an ear weighing a pound, the yield will be forty-six bushels per acre. If two stalks are grown in every hill the yield will be

ninety-three bushels per acre, while if three stalks are grown in every hill the yield will be one hundred and thirty-nine bushels per acre.

However, a certain percentage of the stalks in the field are barren, and a large percentage of the ears do not weigh a pound, so that in order to make up the non-uniform condition of the crop, it is the usual practice to plant from three to four stalks per hill. With the ordinary seed it is almost impossible to secure a high percentage of germination, so that in order to make up for this loss in the stand an extra number of kernels are planted.

Test Germinating Power—Seed corn that germinates less than ninety-five per cent should not be used. The general vitality of such seed must be low, and poor plants and a small yield will result. The ordinary planter does not drop an even number of kernels to the hill. In such cases some hills undoubtedly have too many kernels, while others do not have any. A poor or uneven stand is the cause of greatest loss to corn growers.

In order to get an even stand, it is necessary to use good seed and a planter which will drop an even number of kernels to the hill. Some of the latest improved planters have the plates so arranged that the kernels are dropped one at a time from the seed box to a small receptacle in the runner. This plate is run by a drill attachment so that the kernels drop regularly and uniformly into the runner. When the check lever opens the receptacle the seed for one hill drops directly into the seedbed. By such a machine an even stand can be secured if the seed corn is of uniform size. This arrangement also provides for an even check which is necessary for proper cultivation. This even check can be secured by setting a small stake in the hole made by the wire stake at the end of the field. By sighting

down this row of stakes before setting the wire stake, a straight cross check can be secured.

CULTIVATION

The reasons for cultivation are: 1, to destroy weeds; 2, conserve soil moisture; and 3, aerate the soil. Of these the most important is the conservation of soil moisture. If the ground is not stirred it bakes, cracks open and the evaporation of moisture goes on very rapidly. By stirring the soil through frequent cultivation, thus keeping a loose mulch on the surface, capilliarity is broken up and the moisture retained. The moisture can be used by plants for growth which would otherwise be lost in the atmosphere.

Conservation of Soil Moisture—The Wisconsin experiment station has determined the amount of water necessary to pass through the corn plant in order to mature the plant. This station states that there is not enough moisture in the soils of the cornfields of the United States to mature the largest possible crop. This moisture, taken up by the corn roots, passes through the plant, carrying dissolved plant food which the plants abstract and use in their process of growth, and is given off to the atmosphere through the stomates of the leaves.

These pores of the corn leaves have a regulating influence upon the amount of water given off to the atmosphere. During dry, hot weather they open wide as a bent spring or bow, and transpiration goes on very rapidly. This tends to cool the temperature of the plant as the perspiring of human beings tends to regulate the temperature of the body. So that the water has not only the function of taking food into the plant, but also the important matter of regulating the temperature of the plant.

If from any reason this supply of water is cut off the plant dies, or if the water is supplied in insufficient quantities the plant suffers accordingly, so that it is one object of cultivation to conserve the greatest possible amount of moisture in the soil for use by the plants and to allow of the greatest possible development of the root system of the plants.

Shallow Cultivation—In general, shallow or surface cultivation frequently performed, conserves more moisture than a smaller number of shallow cultivations. On the other hand, an equal number of deep cultivations will likely conserve more moisture than shallow cultivations. By a careful series of tests at the Illinois experiment station this fact was conclusively demonstrated. However, the shallow cultivations uniformly give the largest yields. This loss in yield in the deep cultivations was undoubtedly not due to less moisture, but to injury to the root system by the cultivation. For instance, it was found that by pruning the roots of the corn plants to different depths during three years of experimentation that the yield was uniformly smaller the deeper the root pruning.

Root Pruning—The more roots cut off the smaller the yield. In the cases of the plants, the roots of which were pruned, it was found that after pruning the plants drooped, the leaves rolled up, giving every indication of injury due to lack of sufficient soil moisture. The plants were stunted and never recovered their vitality, but matured earlier than the plants not pruned, although otherwise grown under similar conditions. See Fig 54.

Effect of Weeds on Crop—The point of second importance in corn cultivation is the removal of the weeds. If weeds of any kind are allowed to grow in the cornfield, they use the same elements of fertility as the corn plants, consequently they compete with the

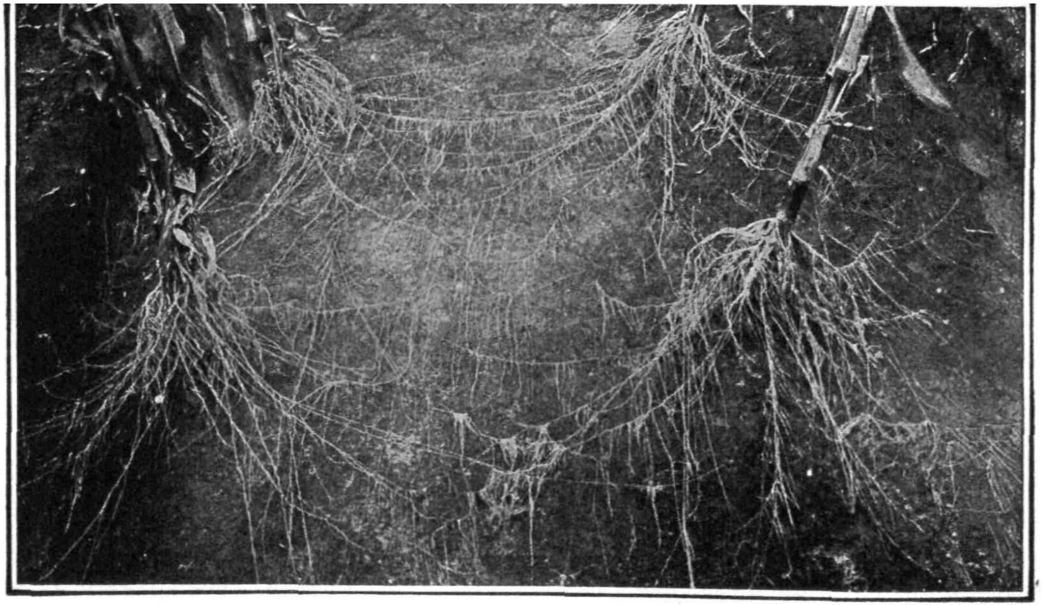


Fig 32—Root Development of Corn in the Field

Soil washed off only to the depth the corn was cultivated

corn plants for moisture, light and plant food. Owing to the struggle for existence constantly going on among the members of the weed families, they are usually particularly fitted to secure their food and to drive out other plants. So that when the weeds grow among the corn plants they usually have the advantage in the ability to live.

In order to get rid of these noxious weeds a large number of kinds of cultivators have been put on the market. In the past the large shovel cultivator, calculated to stir the soil deeply and get rid of all weeds, was the universal cultivator. To-day these implements are not in general use, because it was found they did infinite damage to the corn crop through root injury. In their place has come the small shovel cultivator. Instead of two large shovels there are three or four small shovels attached to each beam. These stir the soil and cut out the weeds, yet do not go deep enough to injure the roots. Along with this kind of machine have come many other types adapted to different conditions of soil and climate.

Culture Implements—These are divided in general into three classes: 1, the harrow; 2, the disk; 3, the knife cultivator. An example of the harrow type is the common weeder. The principle involved here is teeth which scratch out the small weeds, but do not go deep enough to injure the corn roots. In loose, sandy soils this implement is very successful. Large areas can be covered in a short time so that the field can be frequently cultivated. However, it will not remove large weeds or stir the heaviest clay soils.

The second type, or disk, cuts the weeds out with a sharp rolling disk, but does not go deep enough to injure the corn roots. Again, this implement is most successful on the sandy, looser soils, where it can easily move the surface layer of the soil. The first disk

cultivators were so arranged as to throw a ridge along the row of corn. This is a disadvantage and has been eliminated in the latest types of the disk cultivators.

The third type, the knife, or gopher cultivators, as they are sometimes called, scrape off the weeds from the surface of the ground without cutting the corn roots. The knives or blades do not work successfully in all soils. The blade or knife does not easily penetrate the heavy clay soils, and consequently rubs over many of the weeds without cutting them off.

Ideal Cultivator—The best cultivator is that one which stirs the surface of the soil thoroughly to make a loose mulch, which removes the weeds completely, but which does not injure the roots of the corn plant. A root cut off does not reunite, or does not grow out again. The ability of the plant to avail itself of plant food and moisture is reduced just so much. As the greater part of the plant food available for use by the plant is in the surface soil, a very great damage results from cutting off the roots near the surface. Added to this is the fact that any injury to the corn plant, whether to the roots or stem, checks its growth and must result in a decrease of yield.

CHAPTER IX

Silos—Location, Construction and Filling

THE location of the silo should be given careful attention, for silage is heavy and it should not be necessary to carry it very far. The silos should be as near the manger as practicable and convenient to the feeding trough. Many silos are constructed within the barn where the silage is to be fed, or just outside the barn but connected with it by means of a passageway. They are frequently built against the barn with the doors opening inside the building. Having the silo wholly within the barn is not only convenient, but in cold climates where the silage is apt to freeze between feeding periods the protection afforded by the building surrounding the silo is very desirable. In some cases where the silage is to be fed in several buildings it may be well to construct the silo entirely distinct from any of them. In many respects this is most desirable when feeding dairy cows. For if the silo is inside of the barn and any of the silage is dropped and not removed at once, a disagreeable odor arises which taints the air, and being taken in into the lungs of the cows injures the quality of the milk. If it is necessary to have the silo inside of the dairy barn, build a partition between it and the cows in order to keep out all disagreeable odors.

GENERAL CLASSES OF SILOS

There are three different kinds of silos—wooden, stone and brick. The wooden silo is by far the cheapest and in most localities the one to build. Where building stone is abundant and cheap, it may pay to

put up a stone silo, as one of this kind is practically indestructible. Under certain conditions brick silos may be the most satisfactory. The average dairyman and stock farmer will, however, build a round wooden silo with a stone foundation laid in cement. There is less waste of space and silage in a round silo, although many square and rectangular ones are found very satisfactory.

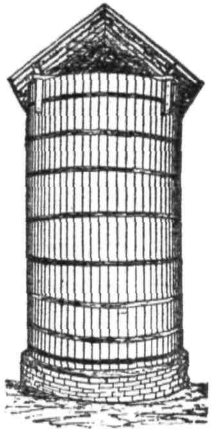


Fig 33—Distribution of Hoops on Stave Silo

At least three kinds of hoops have been used in stave silos, a round, flat and woven wire. All three, of course, are iron, and are held in place by lugs or castings. These lugs of the various hoops should be distributed over the surface of the silo, rather than rise one above another in a straight line. Proper distribution is suggested in the accompanying cut.

Building the Round Silo—There are two methods of building round silos. Both have enthusiastic advocates and seem to be giving satisfaction. The silo built of staves kept together by hoops, and with a stone foundation and concrete bottom, has many friends. The other kind has the same sort of a foundation and base, but the wall in this is built by placing studding eighteen inches apart and covering these on the inside with two or three and on the outside with two layers of half-inch boards, between which are placed layers of tar paper. Both kinds give complete satisfaction in most instances, and the farmer should be governed largely by the difference in cost and his own personal preference.

Where drainage is good it is advisable to start the silo several feet below the surface of the ground. Put in a stone foundation laid in cement, making it one and one-half to two feet thick. For the bottom use

concrete six or eight inches in thickness. Cover the bottom and walls with two or three layers of cement put on with a trowel, then go over the surface with a cement wash. A little dry cement may be worked in to give it a hard finish. The material required for a concrete foundation is enough finely broken rock or gravel to occupy the space, over which is poured a mixture of sand four parts, cement one part, with enough water to make a paste. The stone part of the silo should at least go down below the frost line.

Stave Silo—If the silo is to be made of staves, select the best and most available material possible, white pine if located in the northern states, cypress in the southern and Douglass fir if in the far west. Almost any kind of pine may be used provided the material is perfectly sound, well seasoned and free from knots. The boards should be six inches wide, although some prefer four-inch boards. Those two inches in thickness are best, although one and one-half inches will do for mild climates. If possible select boards which are long enough when placed on end to reach from the top of the foundation to the top of the silo. If the boards are smooth on the inside and along the edges so much the better. Rough boards can be used.

Set up the staves on the foundation, holding them in place by rudely constructed circles just the inside size of the desired silo. These may be made of moderately short pieces of fence board with the corners sawed off, and nailed together so as to form a circle. Use three of these, one at the top, one at the bottom and one about the middle. Place the staves in position around these circles, and hold them in place temporarily by driving nails through the outer edge of the circle and into the stave. In no case must the nails be allowed to go through the stave. Put on hoops which

have been previously prepared and with lugs draw together tightly. The staves when in position should be flush with the inside of foundation. The hoops will be either flat iron bands or iron rods. Iron rods when used as hoops are usually about five-eighths inch in diameter. The lugs make it possible to take up the slack as the silage and silo shrink.

The number of hoops required will depend upon the size of the silo. For one sixteen feet in diameter place a hoop within a few inches of the base of the staves, then let the next one be two feet above. The others may be placed in position, increasing the space with each additional hoop at least six inches until four feet is reached, which should be the limit.

The doors should be provided from the bottom to the top of the silo, and made to fit so as to prevent entrance of air. It is best to cut these out after the staves have been put in place. The edges should be beveled and these bevels should be covered with strips of tarred paper. Before sawing out the door, nail on two cleats, a trifle shorter than the width of the door, so that when the boards are cut out they will remain in the form of a door. The roof for a circular silo may be either conical or of the ordinary form. The conical roof is more difficult to construct, and while it looks better it is in reality of no great advantage.

The size of the silo will depend largely upon the number of animals to be fed. It is not desirable to have a silo less than twenty-four feet deep and sixteen feet in diameter. A silo of that capacity will hold approximately eighty-seven tons. If the silo is thirty feet deep and sixteen feet in diameter, it will hold one hundred and nineteen tons; if thirty feet deep and twenty-four feet in diameter it will hold two hundred and sixty-nine tons. A cow consumes about forty pounds of silage per day, and estimating that she is

to be fed two hundred days, she will consume four tons. Consequently for twenty-five cows one hundred tons must be provided. A good corn crop will yield

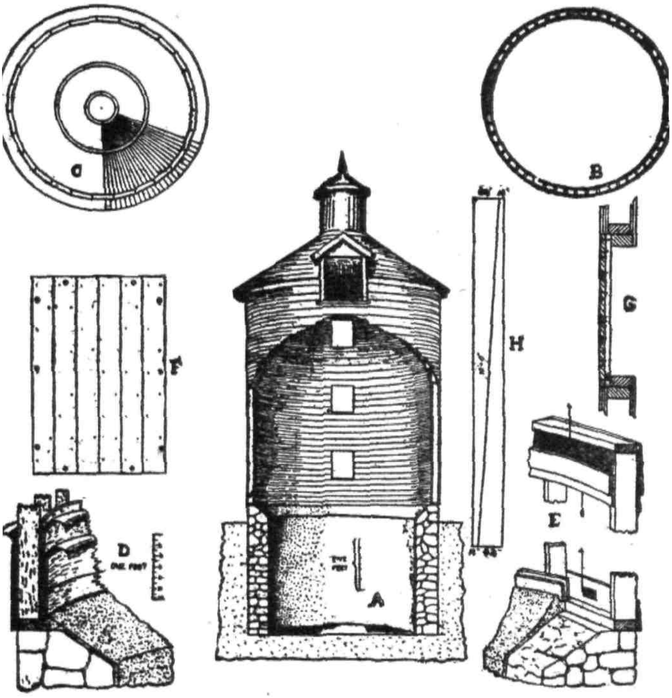


Fig 34—Construction of Studding Silo in Detail

A, portion under ground; B, cross-section showing studding; C, top of silo, showing arrangement of rafters; D, section of wall, showing building paper between layers of boards; E, wall ventilators; F, door; G, cross-section of door and wall; H, cutting rafters.

about ten tons per acre. For one hundred tons of silage, therefore, ten acres of corn must be raised.

Silo with Studding—The other kind of a wooden

silo, that made with studding covered with boards and tar paper, is easily constructed. A wheel or circular sill must be provided to lay directly on top of the foun-

APPROXIMATE CAPACITY IN TONS OF CYLINDRICAL SILOS FOR WELL-MATURED CORN SILAGE—KING

Depth in ft	INSIDE DIAMETER IN FEET										
	15	16	17	18	19	20	21	22	24	25	26
20	58.8	67.0	75.6	84.7	94.4	104.6	115.3	126.6	150.6	163.4	176.8
21	62.9	71.6	80.8	90.6	100.9	111.8	123.3	135.3	161.0	174.7	189.0
22	67.4	76.5	86.4	96.8	107.9	119.6	131.8	144.7	172.2	186.8	202.1
23	71.4	81.3	92.1	103.3	115.1	127.5	140.6	154.3	183.6	199.3	215.5
24	76.1	86.6	97.8	109.8	122.1	135.3	149.2	163.7	194.9	211.5	228.7
25	80.6	89.6	103.6	116.1	129.3	143.3	158.0	173.4	206.4	223.9	242.2
26	85.5	97.2	109.8	123.0	137.1	151.9	167.5	183.8	218.8	237.4	256.7
27	90.2	102.6	115.8	129.8	144.7	160.3	176.7	194.0	230.8	250.5	270.9
28	95.0	108.1	122.0	136.8	152.4	168.9	186.2	204.3	243.2	263.9	285.4
29	99.9	113.7	128.3	143.9	160.3	177.6	195.8	214.9	255.8	277.6	300.2
30	105.0	119.4	134.8	151.1	168.4	186.6	205.7	225.8	268.7	291.6	315.3
31	109.8	124.9	141.1	158.2	176.2	195.2	215.3	236.3	281.8	305.1	330.0
32	115.1	135.9	147.8	165.7	184.6	204.6	225.5	247.5	294.6	319.6	345.7

NECESSARY DIAMETER OF SILOS FOR FEEDING DIFFERENT NUMBERS OF COWS WHILE REMOVING 2 TO 3.2 INCHES SILAGE DAILY—KING

No of cows	Silo 30 ft deep, no partition, mean depth fed daily 2 inches				Silo 24 ft d'p, with partitions, mean depth fed daily 3.2 in			
	Contents		Round diameter in feet	Square sides in feet	Contents		Round diameter in feet	Square sides in feet
	Tons	Cu ft			Tons	Cu ft		
30	108	4,091	15	12x14	108	5.510	17	16x16
40	144	6,545	16.75	14x16	144	7,347	20	18x18
50	180	8,182	18.75	16x18	180	9,184	22	20x20
60	216	9,818	20 5	18x18	216	11,020	24	22x22
70	252	11,454	22	20x20	252	12,857	26	22x26
80	288	13,091	22.5	20x22	288	14,691	28	24x26
90	324	14,727	25	22x24	324	16,531	29.75	26x28
100	360	16,364	26.5	24x24	360	18,367	31.25	28x28

dation. This is usually constructed of the same kind of material as the studding, say two by eights. It is made by nailing a number of pieces together and beveling and rounding the ends so that a complete

circle is formed. The studs are placed in an upright position, toenailed to the sill and secured at the top by means of a plate constructed similar to the sill.

The frame is now ready to be covered and lined. The best results for the lining are secured by using two or three layers of half-inch boards between which layers of tar paper are placed. First nail a layer of the

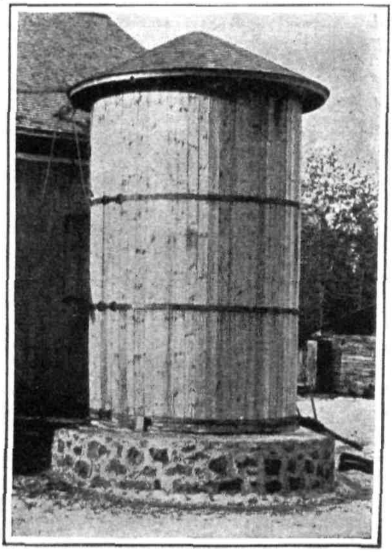


Fig 35—Cheap Stave Silo
In Wisconsin

boards horizontally as close together as possible, then put on a layer of good tar paper and cover this with a second layer of boards. Put on another layer of boards, etc, taking care to break joints with each previous layer. For covering the outside put on a layer of half-inch boards, as before indicated, then a layer of

tar paper, and complete the outside with a layer of ordinary weather boarding or shiplap placed horizontally. Put on a conical or ordinary roof of shingles. Provide doors as nearly air tight as possible. The silo is then ready for filling.

The ventilation of this kind of silo is very important. There must be a properly protected opening through the roof from which the gaseous products of fermentation may escape. The walls must also be ventilated. On the outside near the bottom cut an opening or bore auger holes in the exterior wall and cover with wire netting. Do the same on the inside near the top. Have at least half a dozen or so of these ventilators in each silo, or better still one set for each space between studs. Circulation of air will be secured and the construction material will last better.

Brick silos should be constructed with two or three walls and air spaces of one to four inches between the walls. The total thickness of the wall should not be less than two feet. The inner walls can be made of broken brick and thus reduce the cost. The bricks should be laid in cement, and the interior of the silo should be covered with a coating or two of good cement. Have the masons leave a door three feet high at the bottom of the silo, arching it over at the top. Build up two or three feet, then leave another door, and so on. A brick silo sixteen feet in diameter and twenty-four feet deep will require about twenty-one thousand brick.

In building a stone silo, prepare the foundation and bottom as for a wooden, then build up the walls at least twenty-four inches thick. When the building is completed, roof it over carefully and give the interior a coating or two of cement so that the surface will be as smooth and air tight as that of a cistern. If the stone wall is properly constructed there

will be no necessity for protecting it on the outside. If, however, this is considered necessary, place studding against the outside of the wall and cover with weather boarding. The stone silo will cost seven or eight dollars a cord—stone, cement, lime and labor. It takes thirty-six cords of stone to make a silo sixteen feet in diameter and thirty feet deep. A silo of this size holds about one hundred and twenty tons.

Cement Lining—Of late years many wooden silos have been lathed on the inside and given two or three coatings of cement. This has worked well where the laths are placed on a solid wall, such as is found in the average wooden silo. When the work is carefully done the resulting silo is in effect a cement silo, except that the wooden parts are apt to decay and are not as durable as stone or brick. Some dairymen report good results from the use of patent lathing nailed direct to studding and properly cemented. The studding must be close enough to each other so that the layers of cement will not spring and crack. This is more liable to occur in a square than in a round silo.

PUTTING CORN INTO THE SILO

Corn is the great silage crop in the United States. A variety with heavy foliage and stalks of medium size planted early in spring is most desirable. This, if kept clean and well cultivated throughout the season, will yield at the rate of ten to fifteen tons of green forage per acre. When the plants are fairly well matured, say as the ears are beginning to glaze, and when the indentations are well marked, is considered the most desirable time for cutting. This is usually just after what is termed the roasting ear stage. Considerable judgment will be required, even with this in mind. With some varieties of corn and during some seasons

maturity is not complete until after that period. The farmer will soon learn to judge as to the best time for cutting, remembering always that immature corn usually results in sour silage, while fairly well matured fodder gives sweet, palatable feed. Where a large amount of silage is to be handled by a comparatively small force of men, it will be necessary to begin cut-

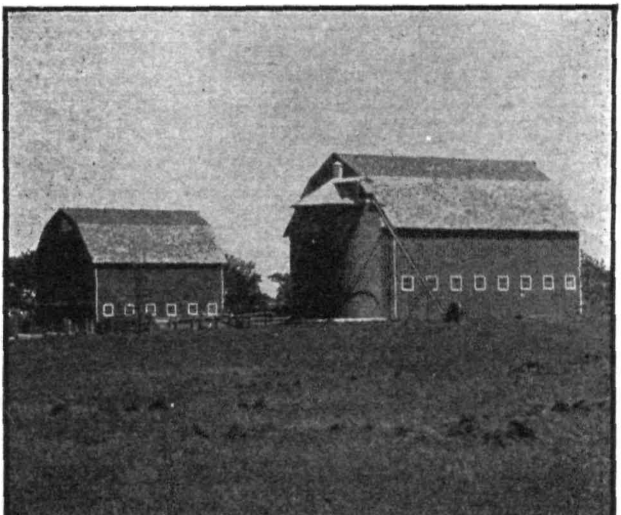


Fig 36—Silo Attached to Barn

ting rather early and continue until the crop is past the most desirable stage.

According to some Pennsylvania experiments corn rapidly increases in the total quantity of dry matter as it approaches maturity. These particular tests show that the total amount of digestible matter was much

greater when nearly mature than when cut earlier, and that the digestibility decreased at a slower rate than in the case of other forage crops. The total yield of digestible material, for instance, was thirty to thirty-six per cent greater when the crop was fairly well matured than at silking time. When the corn begins to get too dry, the silage may be greatly benefited by the addition of water, either to the cut corn as it comes out of the cutter, or to the material as it is deposited in the silo. Some Michigan farmers have been well satisfied with cutting their dry fodder direct from the shock, putting it into the silo and thoroughly moistening it. They claim that the material becomes succulent, and is a much more desirable stock feed than when fed as dry fodder. When corn has been frosted and allowed to dry out it can be made into silage. Fair feed results, although it is not so good as the green silage.

Placing corn in the silo usually increases the digestibility of the crude fiber. On the other hand, there is always some loss from fermentation and a slight decrease in the digestibility of other food elements. This partially offsets the benefit. Silage, however, is better than cured corn fodder, as field curing decreases the digestibility of many substances, particularly of the fiber. Numerous experiments show that the decrease in digestibility is about the same in some elements in field-cured fodder, but the digestibility of the fiber is greatly increased in silage and decreased in fodder.

Loading and Hauling—The modern corn binder is very satisfactory for cutting corn for the silo. Where only a small area is to be handled, say ten acres, the old-fashioned corn knife or some of the sled cutters answer very well. If the cutting is done by hand, the corn should be deposited in bunches so that it can be loaded easily on a wagon.

A low wagon is very essential for transporting the

green corn to the silage cutter. The one represented in Fig 37 has been used by the Wisconsin experiment station and by many practical farmers. The running gears of an old wagon may be utilized. The stringers are four by eight inches and eighteen or twenty feet long. They can be connected to the front axle and held in place by means of an elongated kingbolt provided with a nut and washer. From the back axle they are suspended by means of two three-fourths-inch bolts with washers below and hooks above. The wagon hounds are kept from tipping up by means of a short piece of two-inch oak board extending from

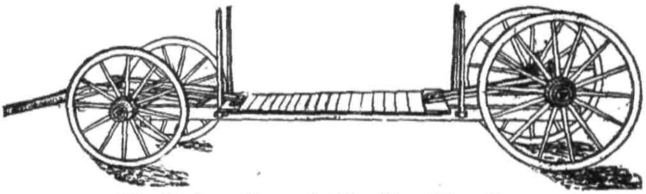


Fig 37—Low Wagon for Handling Silage Corn

the kingbolt to the back standards. The floor is usually made of inch oak boards.

Cutting for Silo—Corn is conveyed to the machine and there cut into one-inch and one and one-half-inch lengths. Some feeders prefer one-half and three-fourths-inch lengths, but these are liable to cause soreness of the mouth in cattle, particularly if the material is hard. The cut corn is elevated or blown into the silo. Care must be taken to have it evenly distributed. If a conical heap is allowed to form in the center, the heavier portions, such as the butts and pieces of ears, roll to the outside and the lighter portions remain in the middle. This results in an uneven distribution of the silage, which is very undesirable. Keep this heap raked down, or by means of a flexible tube of some

kind attached to the end of the carrier, direct the material to all parts of the silo. If this is carefully done, and it is tramped down compactly, the results will be most satisfactory. In many cases, in fact, in almost all, it is desirable to fill about half full, allow to settle for a day or two, then fill to the top, allow the silage to settle for several more days, then refill. This may be accomplished easily where two or more silos are being filled on the same farm. Work one or two days on one, then move to the other and work a day or two. Do the greater part of the tramping around the edge.

Covering—The matter of covering the silage is still in dispute. Some cover with hay or straw, others with some kind of cloth, still others with boards or straw, wet down well, while a few cut several loads of very green corn very fine, put on top and sprinkle with water. A mold soon develops and forms a dense mass which completely excludes the air. In many places no covering at all is used. The upper eight or ten inches molds and seals the silo, and in this way prevents the entrance of air.

Handling Stalks Uncut—In some neighborhoods corn is put into the silo without cutting. Those who practice this method claim that silage is sweeter and much more palatable, especially for horses, than when the stalk is cut. The ear, being left undisturbed in its husk, retains its natural flavor and aroma. Air gets into the interior of the stalk and ear when it is cut up into small pieces and more or less decomposition results. This is not so apparent when the stalk is preserved whole. The objection to the system is that it is more difficult to compact the whole corn so as to exclude all the air. As a consequence there is considerable more danger of loss. Another objection is the greater difficulty in handling the stalks when putting them into the silo and when they are to be taken out. This,

however, is largely overcome by cutting the corn with a binder and using a double harpoon fork for elevating and dropping into the silo. The green corn is loaded on the low wagons in sections so that the fork can handle it nicely. In taking the whole silage out for feeding the same apparatus is used, merely reversing the process.

Fig 38 shows how Mr Hodgson of Wisconsin places the bundles. When the silo is square they are placed at *a*, the dotted line representing the top of the silo. In a round silo the bundles are laid round and round as at *b*, and have this appearance when seen

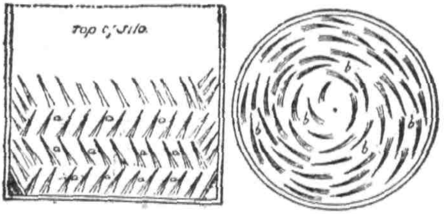


Fig 38—Placing Bundles in Square and Round Silo

from above. Mr Hodgson's round silo holds one hundred and thirty tons. He has stored whole corn in this manner for twelve years and is perfectly satisfied. He claims that it is sweeter and that his animals eat it more readily than when cut.

The cost of putting up silage will depend upon the distance from the field, the implements used, etc. As a general rule and with ordinary appliances silage can be put up for about forty cents per ton. Some farmers have done this work for twenty to twenty-five cents per ton and some have paid sixty to eighty cents.

The preserving of feed in the silo makes it possible not only to secure succulent forage in winter, when

green crops are not available, but also provides green fodder during drouths in summer and autumn. A number of experiment stations have tested silage two or three years old and find that where it kept well it was just as good as when only six months old. Practical farmers have had the same experience and find it much the cheapest method of supplying succulent feed

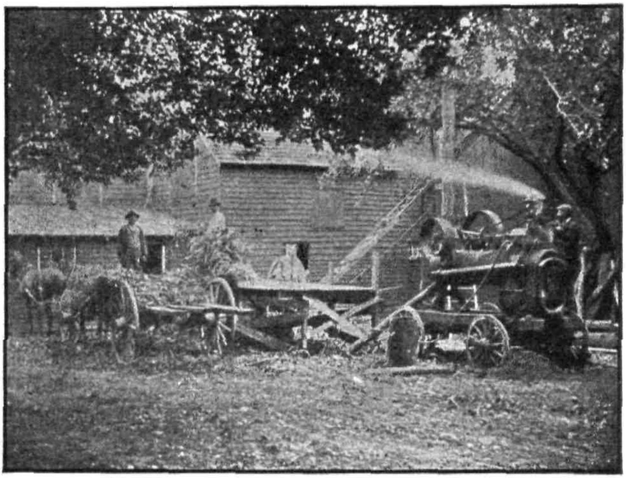


Fig 39—Filling the Silo

during that part of the year when pastures are short. If not needed the first summer it can be held until the next winter or even the next summer. Many are coming to believe that soiling and the silo are more economical than trying to provide pasturage for farm animals.

Preserving Green Crops Without Silo—Various attempts have been made to preserve green crops without a silo. The plan is to stack them in the open air

as compactly as possible. The outer layer will decompose and form a coating which will exclude air from the interior. The stack then in a sense becomes a silo. Only a few attempts have been made with corn, but with clover, cowpeas and soy beans numerous tests have uniformly resulted in disappointment. It is an exceedingly hazardous method of preserving the green feed. There is too much danger of the decomposition extending all the way through, or at least far into the stack. Some Illinois farmers, having more corn than they could put in their silos, tried this method. They cut it very fine, stacked it in the open air, tramped down slightly and covered with hay. More than half the fodder rotted, but they claim that even this was not a total loss, as cattle and sheep ate it readily after it became thoroughly dry. They did not care, however, to repeat the experiment.

CHAPTER X

Harvesting

EXISTING agricultural conditions are beginning to have an influence upon the method of harvesting corn in the middle and western states. While the rich prairie soils contained an unlimited amount of plant food little attention was given to harvesting corn except to see that the largest immediate returns from each individual crop were secured. No thought, or at least very little, was given to the matter of keeping up the fertility of the land by returning to it any part of the grain grown upon it from year to year. Where fodder was needed for farm animals the corn was cut and preserved in shocks until needed for feed. The general rule, however, was to allow the corn to remain in the field until thoroughly matured, then to husk the ears from the standing stalks. The grain was either fed or sold direct to the elevator. The stalks were allowed to remain in the field until spring, when they were broken, raked and burned.

By this method absolutely nothing was returned except the ashes from the stalks, and these were so poorly distributed as to be of little value. The productive capacity of the soil began to decrease, until to-day the chiefest problem confronting the corn belt farmer is how to harvest and dispose of his corn crop and at the same time retain the greatest amount of valuable fertilizing elements—potash, phosphorus and nitrogen. The nitrogen is obtained by growing legumes, particularly clovers and cowpeas. How to retain the potash and phosphorus is the great problem.

Progressive farmers realize that one of the best ways is to raise as much stock as possible and feed the grain on the farm. If this is done a large part of these two valuable mineral elements will be returned to the land in the manure. So long as cattle and hogs bring good prices it is not difficult to make a profit in this way, but when they are cheap very careful management is required. Because of this, it has come about that more and more attention is being given to the methods which will result in securing the entire corn plant in the best possible condition. The old and somewhat wasteful method of husking from the standing stalk, then selling the grain, still obtains, but the saving and feeding of the fodder is a larger and larger item each year. The silo finds a place in every dairy section, and is becoming better known in the strictly beef and mutton growing parts of the country. However, the great bulk of the fodder crop will for many years be cut and cured in the field and afterwards fed in the dry state.

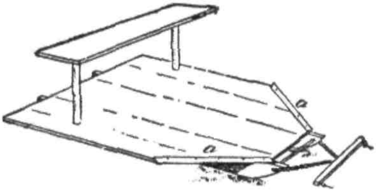


Fig 40—Simple Corn Cutter

One of the cheapest corn harvesters possible is shown in accompanying cut. It is simply a sled with wide platform and sharp-cut edges at *a*. This sled is drawn between two rows of standing corn. The stalks are cut off by the cutters at *a*, and caught by two men who stand or sit on the sled. When the armful is gathered, the horse is stopped and the corn is taken to the shock and placed in position. By placing wheels at the front and rear of the sled the draft is greatly reduced.

INFLUENCE OF MATURITY UPON YIELD OF DIGESTIBLE SUBSTANCE

The stage of development of a plant at the time it is harvested may materially affect its value as a feed,

in the quantity of digestible material produced and in the palatableness of the fodder. Aside from these considerations, the greater certainty and convenience in curing the more mature plants, the mechanical loss of the finer portions due to storms or to the handling of the plants in harvesting when they are too mature, affect in practice, to a considerable degree, the time of harvesting each crop independently of the yield and the palatability of the product. It is also true that in handling large areas of any crop it is not convenient or profitable to arrange for sufficient force of men and machinery to harvest the entire crop in precisely the stage that combines the maximum yield with the highest degree of palatability. Hence the harvest must usually begin at a stage when some sacrifice in yield is made, and extend to the point where loss in palatability is sustained.

In the case of the corn plant, the impression has long prevailed that after the roasting ear stage is reached, nothing is actually added to the plant, that it then contains all the nutrients it will ever contain; that the non-nitrogenous compounds then consist chiefly of "sugar," which is to some extent at least converted into indigestible compounds in the process of ripening, and that by allowing it to ripen a loss of digestible material occurs by reason of these changes.

WATER AND DRY MATTER AT DIFFERENT PERIODS*

Date of cutting	Stage of growth	Corn per acre TONS	Water per acre TONS	Dry matter per acre TONS
July 30	Fully tasseled	9.0	8.2	0.8
Aug 9	Fully silked	12.9	11.3	1.5
Aug 21	Kernels watery to full milk	16.3	14.0	2.3
Sept 7	Kernels glazing	16.1	12.5	3.6
Sept 23	Ripe	14.2	10.2	4.0

*Henry, Feeds and Feeding; from New York (Geneva) station.

That the position is wholly erroneous, and that the plant continues to gain in dry substance until fully mature, is clearly shown by the results of numerous careful experiments.

It will be observed that the most rapid gain in pounds of dry matter per acre occurred between the roasting ear and glazing stages, and that there was a material gain from the glazing stage to the time when the plant was ripe. Had the crop in this case been harvested in the roasting ear stage, the yield of dry matter would have been two and three-tenths tons per acre, while four tons were secured when the plants were fully ripe. In other words, the yield was practically doubled between the roasting ear and full ripeness.

An elaborate study of this problem by Jordan at the Maine experiment station confirms the results already quoted and adds to our knowledge of the changes that take place in the composition of the plant during the later stages of growth. A summary of the results is shown in the following table:

YIELD OF CORN AT DIFFERENT STAGES GROWTH

Stage of development when harvested	Days in period of growth	Dry matter per acre LBS	Gain dry matter per acre each period LBS	Daily gain dry matter per acre each period LBS
Ears beginning to form	..	3064	....	....
A few roasting ears	13	5210	2146	165.0
All roasting ears	7	6060	849	121.3
Some ears glazing	8	6680	620	77.5
All ears glazed	9	7039	358	39.8
Total increase	....	....	3974	....

In this case the yield of dry matter per acre was more than doubled in thirty-seven days, or between the silking stage and the fully glazed stage. It will

be interesting to see what the character of gain was. The table below furnishes this information.

DIFFERENT CLASSES OF COMPOUNDS PER ACRE AT DIFFERENT STAGES

Stage of development when harvested	Ash LBS	Protein LBS	Fiber LBS	Nitrogen free ext LBS	Sugars LBS	Starch LBS	Fat LBS
Ears beginning to form......	286	458	812	1428	358	....	80
A few roasting ears..........	339	612	1214	2892	1064	108	154
All roasting ears.............	376	690	1192	3621	1248	297	182
Some ears glazing............	372	639	1291	4177	1407	357	200
All ears glazed...............	416	650	1309	4457	1161	1083	200
Gain after first cutting......	130	191	497	3029	802	1083	129
Gain after second cutting...	77	38	95	1565	97	975	55

"Two facts are clearly shown. First, that the latter growth of dry matter in the corn plant is made up chiefly of non-nitrogenous compounds; second, a large percentage of these compounds consist of sugars and starch, substances that are the best of their class for the purposes of animal nutrition."

Not only is the yield increased by allowing the plant to mature, but contrary to general opinion the mature material is actually more digestible, as is shown by the following summary of American digestion experiments compiled by Jordan:

DIGESTED FROM 100 PARTS OF ORGANIC MATTER

	Corn fodder, average	Silage
Cut before glazing, 13 experiments....................	65.7	67.4
Cut after glazing, 10 experiments....................	70.7	73.6

Applying these figures for corn fodder to the yields shown by New York experiments in the preceding table, it is found that an acre yielded of dry

digestible matter when in roasting ear stage one and five-tenths tons, and when fully ripe two and eight-tenths tons. Again when the field-cured fodder is

Fig 41—Corn Ready to Cut for Fodder

allowed to remain in the shock until required for feeding, as is the custom throughout much of the corn belt of America, it has been found that the more mature plants keep much better than those harvested green,

and the season is usually sufficiently advanced by the time the corn is reasonably mature to escape the warm wet weather that is so destructive to feed of this class.

In the light of these investigations and the experience of the most successful farmers, it is considered that when the outer husks and the leaves below the ear have turned yellow but have not become dry; when the stalk and leaves above the ear begin to show the golden tinge, corn will as nearly approximate the maximum yield without sacrificing palatability, and present a condition when the material may be put up in large shocks without danger of molding. At this stage the kernels are fully glazed and practically mature.

CUTTING CORN FOR FODDER

Just how to cut and care for corn desired for fodder is a great problem. When shall it be cut? How long shall it remain in the field? Shall it be stacked, stored in the barn, or shredded and baled? The opinion prevails that corn cut on the green order, provided it can be cured perfectly, is more palatable and consequently more profitable. Under certain conditions this may be true. When fodder of very high palatability is needed for young growing stock or for animals being fed to the limit, it will undoubtedly pay to cut the fodder rather early, say about the roasting ear stage, and when the leaves at the bottom of plant have just begun to turn. At this stage the fodder contains a large amount of water and has a high protein content, but is deficient in starch, sugar, gum and the like. It is also comparatively light in weight at this time, and the output per acre is thirty to fifty per cent smaller than if allowed to more completely mature. The bulk of the corn crop should not be cut until considerably later in the season, when the kernels have begun to

harden, and the warm sun of autumn has developed these starches, sugars and gums in larger quantities.

DATE OF MAXIMUM HIGHT, WEIGHT AND FOOD CONTENT

Tests at the Illinois experiment station, averaging the results for a series of years, indicate that so far as hight is concerned, the maximum is attained during the latter part of August, but the greatest weight does not occur ordinarily until the middle of September or a little later, depending upon the season. At this time also it is interesting to note that the water content of the plant is much smaller than a few weeks earlier. The protein content has not increased much up to this time, but the starch has almost doubled during the last four weeks and the sugar increases considerably. Of course, fiber increases also, but not in so great a proportion as the starches and sugars. The middle of August the corn examined contained about 81 per cent of water, a little over 1 per cent of ash, 1¾ per cent of protein, 5 1-3 per cent of fiber, 10½ per cent of starch and ½ per cent of sugars, gums, etc. About one month later, when the crop had attained its greatest weight, it had the following composition: Water 67¾ per cent, ash 1 2-3 per cent, protein 2 2-3 per cent, fiber 6¾ per cent, starch 20 1-3 per cent, sugars, gums, etc, 1 per cent. This shows a rapid increase during the last four weeks. Early in October the change was still more marked, analysis showing the following composition: Water 56 per cent, ash 1¾ per cent, protein 3½ per cent, fiber 9 per cent, starch 28 per cent, sugars, gums, etc, 1 1-3 per cent. In 1889 the crop reached the greatest hight the first week in August. It reached its greatest weight of dry matter the third week in September, the increase during the month being nineteen per cent of its total weight of dry mat-

ter. In 1890 the maximum hight was attained the third week in July, and the maximum weight the second week in September. During September there was a gain of fifteen per cent in total dry matter. In 1891 the greatest hight was reached August 1, at which time forty-six per cent of the total dry matter produced had been developed. By the second week of September the maximum weight was attained, or fifty-four per cent during the last weeks of growth.

Do Not Harvest Too Early—These tests go to show the great loss, other things being equal, in harvesting corn too early. Then there is the additional danger of the immature plant not curing properly unless the weather is very dry. The juices contain such a small percentage of starches and sugars that undesirable ferments are likely to gain a foothold, causing a low quality of forage. When the starches and sugars are more fully developed later in the season a much sweeter and more wholesome product is secured under favorable conditions. The late Professor G. E. Morrow, in summarizing this work, stated that observations show that the percentage of dry matter in the corn plant, both stalk and ear, increases up to the time of maturing, but it has not been shown that the digestibility decreases as maturity approaches. It seems clear that considerable loss in total food value of the corn crop is often sustained by cutting it at too early a stage, whether designed for silage or cut for dry fodder. The percentage of water in the young corn plant is surprisingly large, while the quantity of dry matter and food value is much less than that found as the plant approaches maturity. On the other hand, it frequently happens that considerable loss is sustained by allowing the crop to remain in the field until fully matured. This loss comes from storms, destruction from animals, birds, etc.

Fig 42—Corn Binder at Work in Field

BEST TIME TO CUT CORN FOR FODDER

Extensive experiments to determine the best time for cutting corn have been conducted at the Pennsylvania station, at one time and another, and the results are remarkably uniform, all pointing to the advisability of allowing the corn to become quite well matured before cutting and shocking. In 1891 Professor Hunt made three cuttings. The first was September 1 and 2, when the leaves and husks were green and the kernels mostly in the roasting ear stage. The second cutting was made September 25, when a few of the lower leaves were dead, but the husks were still green. The kernels on about three-fourths of the ears were dented. On some ears they were quite hard and on others still unglazed. The third cutting was made October 7 and 8, when two-thirds of the leaves were dead and the kernels mostly hard. Fodder from these cuttings was carefully analyzed. The fodder was then fed to milch cows. The combined results of this investigation show that the most and best food for making butter was secured when the fodder was cut September 25. The yield of fodder was greatest when the corn was cut after being well ripened. Fodder allowed to remain in the field ten to fifteen weeks after cutting lost twenty per cent in value.

Taking into consideration all the Pennsylvania experiments along this line, Professor H. B. Armsby points out that corn should be allowed to mature pretty fully before cutting. In every experiment the amount of dry matter increased very rapidly after growth had apparently ceased. This increase takes place in the grain and consists of the storing up of starchy material and fat. Part of this comes from the air and part of it from the leaves and stalks. Where early harvesting is desirable less loss occurs by planting some of the large, rank

varieties of corn. Thick seeding gave a larger yield of feed than thin and the fodder was in better condition.

Practically these same conclusions were arrived at in Maine. There it was found that mature corn contains much the larger proportion of the more valuable carbohydrates—the sugars and starches. The starch especially increased, in some cases as much as fourteen per cent. The large-growing varieties from the west should, according to the Maine station, be harvested before they are quite mature, but flint corn should be allowed to stand until well ripened.

Cutting and Shocking—After the important matter of time of cutting has been decided, the next step is cutting and shocking the corn. Other things being equal, a large shock should be planned for, especially in the west, where the fodder is seldom housed. A shock sixteen hills square is the favorite in most sections, although in some localities where the corn is very heavy a twelve-hill shock is the favorite. In the east and north shocks are seldom more than eight hills square. The climate also has something to do with the size of the shock. In the humid regions small shocks are not desirable. Care must be taken in putting them up. It seems most desirable to start the shock, cutting about one-fourth of the fodder, allowing it to dry out thoroughly, then putting on another fourth, and continuing until the shock is completed, allowing at least one day to elapse between each cutting. If, however, rain comes during the cutting, much more of the fodder will be injured. Great care must be exercised in standing corn about the shock, so that the shock will not twist or blow down. This can be accomplished by care in starting. Set the armfuls or bundles down firmly and press the tops together. Place the butts well out from the base, and when the

shock is completed tie at the top lightly with a stalk of green corn or a cord.

The corn binder is coming into use rapidly, some big farmers operating as many as ten at one time. They are so constructed that corn can be handled even though it be badly blown down. It operates best in corn of medium size. The cost of twine is largely offset by the smaller amount of labor required for shocking and hauling. Where the crop is on the green order there is more danger of it molding under the band when placed in the shock than if cut by hand. If it is not practicable to have a corn binder, many of the numerous drag cutters in the form of a sled with cutting knives on each side answer very well and save much hard work. They are simple and can be constructed at home with the aid of a blacksmith. The old-fashioned method of cutting with a hand knife still obtains in many places.

The corn binder (Fig 42) is cutting corn sixteen feet high and doing good work. Where the stalks stand up well and the field is free from weeds the binder will cut and handle corn of almost any size. Corn of medium hight it will take care of even when badly down, provided the stalks do not lean in the direction the machine is being driven. Two strong horses find no difficulty in drawing the binder all day.

Storing the Fodder—The common practice in the corn belt is to let the fodder remain in the field until wanted. This results in a loss of about twenty per cent, depending upon the weather, size of the shock, etc. Where large shocks have been made this loss, of course, is reduced to the minimum. Stacking corn fodder after it has been thoroughly dried is common where small quantities are to be taken care of. This also is true in the older states, where the fodder is stored in the barn.

Use of Shredder—In the big corn growing sections the fodder shredder and husker is becoming more

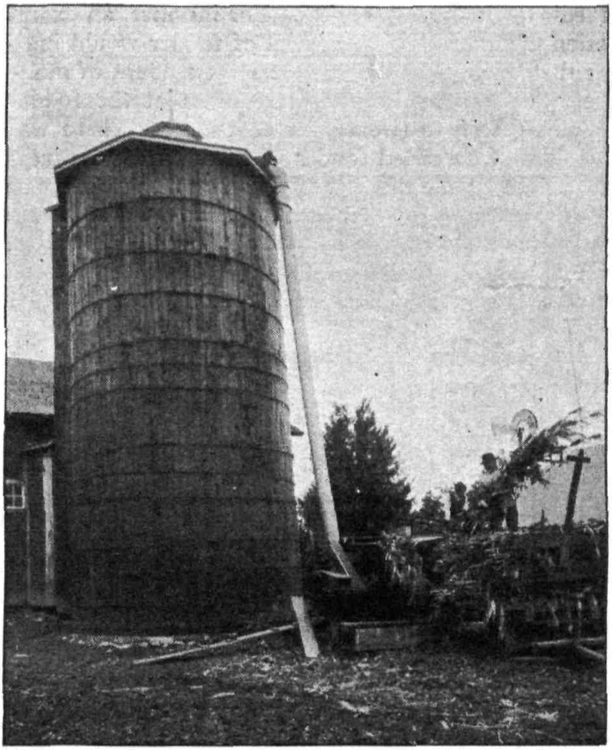


Fig 43—Filling Silo with Blower

This is the very latest in silo filling machinery. A powerful fan drives the cut cornstalks through the long blowpipe into the silo. It is as much superior to the old style of elevator as the wind stacker of the modern thresher is to the old bell stacker. By using a flexible spout at the upper end, the cut corn can be directed to any part of the silo. There are no belts and pulleys to get out of order. It is for sale by all the leading manufacturers of silo machinery.

and more popular. The first objection to this machine was that there was difficulty in keeping the shredded

fodder. The tendency to mold seems much greater than in hays and other kinds of rough feed. It has been determined, however, that this difficulty can be remedied by thorough curing. For instance, an examination of a lot of hay and a lot of fodder would indicate that they contain about the same amount of moisture. Analysis will show, however, that the fodder contains fifteen to twenty per cent more. There was some loss of shredded fodder when the machines were first placed on the market. Of late there has been but little complaint. Another drawback is the cost of operating the shredders. In many localities this is so high as to be almost prohibitive, but with improved machinery and a better acquaintance with the shredded fodder this difficulty will gradually disappear. The common practice in most localities is to charge one dollar to one dollar and a half an hour, or one dollar to two dollars per acre. The husked corn is run into wagons and taken to market, while the fodder is run into a barn or a baling press.

Extensive experiments by practical feeders and experiment stations indicate that unhusked fodder is the most palatable. There is an aroma about the ear taken direct from the husk by the animal that is lost if it is removed and stored in a crib. Not only does the animal like the feed better, but a larger amount is consumed and gains are more rapid. Where large-eared varieties are grown it may be necessary to break the ears before giving to cattle, but this should be done just before feeding. This is much more widely recognized by dairymen and by feeders than ten years ago.

HUSKING STANDING CORN

By far the most serious task in raising corn is the matter of husking it in the field. Up to date no practical machine adapted to this purpose has ap-

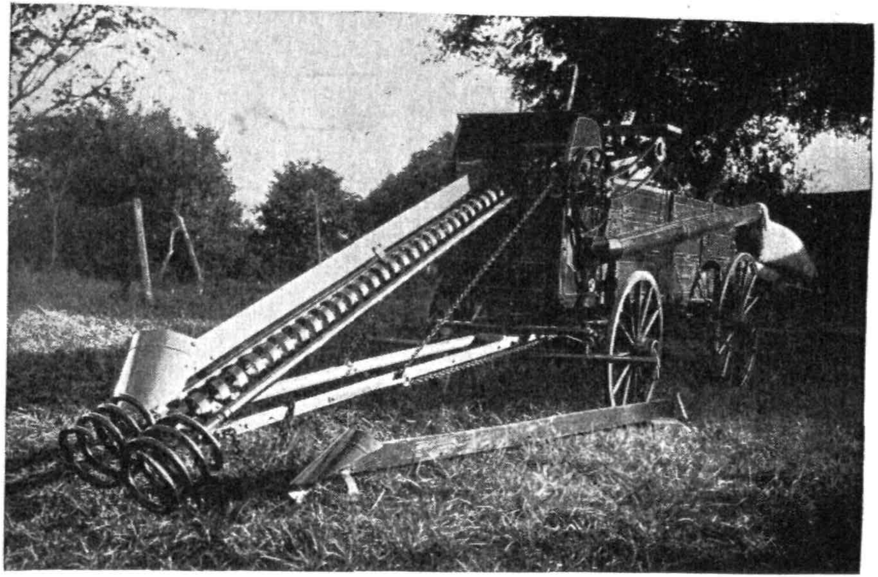


Fig 44—The Latest Corn Husking Machine

peared. Many have been tried but they usually fall short in some important particular. None of them has become popular, and a fortune awaits the man who perfects a thoroughly practical corn husker, which will be as successful relatively as the modern husker is for corn fodder.

When corn is to be husked direct from the standing stalk it should be allowed to mature quite thoroughly, particularly if it is of a variety with large ears and large cobs containing a high percentage of moisture. This must be determined by examination. Some seasons husking begins the latter part of September in northern latitudes, while in others it is not safe to begin husking until the middle or end of October. The time will also depend largely upon the variety. Early maturing kinds have small ears and small cobs and they can be husked much earlier than late maturing and large ear varieties. Corn when first placed in the crib contains thirteen to thirty-five or forty per cent of moisture.

A common practice in the great corn states is to start through the field marking a "down" row. Husk two rows to the left of the wagon and the one row that is under it. Go around a good-sized "land" in this manner. The next time through the field and every succeeding time thereafter have the team straddle the last husked row next the corn that has not been husked. This will prevent the necessity of picking up a down row each time and will enable the husker to do his best work. The ordinary wagon box will hold from twenty-five to thirty bushels. Where the corn is exceptionally good a skillful husker will be able to more than fill one wagon box in half a day. The capacity of a box may be increased by putting on additional sideboards which any farmer can make himself. On the right side of the wagon box it is desirable to

place one or two extra boards to act as bump boards. The husker need not then use so much care in throwing in his corn, which will enable him to do more work. A good husker so gauges the distance from the row to the wagon box that it is not necessary for him to look where he throws the ear. If seed corn is to be selected at this time place a box or barrel in one end of the wagon and into it throw all the ears from strong vigorous stalks, provided they come near the desired type. When unloading throw out all soft, partially rotted or smutted ears and feed at once to cattle. It is much better to look after this carefully than to run the risk of a bad ear spoiling a lot of corn in its immediate vicinity.

As soon as the husking is started the work should be pushed as rapidly as possible, for the corn ought to be out of the field by Thanksgiving time. Comparatively good weather frequently prevails up to Christmas, but there are always some stormy days which make it difficult to get the corn out and very frequently result in loss. If corn is in the field until Christmas there is very little likelihood of getting it out until spring opens. This is very bad farming, as great loss is sure to follow. Get all other farm work out of the way before husking begins, then devote all the time to this work. Other things can wait, but this cannot. When the husks are loose, the corn dry and ears large, one man can easily husk fifty to fifty-five bushels a day. Some men can accomplish much more and many much less. Husking thirty-five to forty-five acres during one autumn is enough for one man, and he must not have too many chores to do in order to get through to good advantage. An attempt to husk more will usually extend the work into cold, snowy weather.

The illustration (Fig 44) shows a corn husking machine invented by J. L. Locke of Nebraska and patented September 11, 1901. It has been given fair trial and the inventor is much pleased with its work. Just what its future will be, time and further testing will determine. The husker is comparatively simple and is operated by one man. By means of two large spiral coils working on either side of an elevator which projects beyond the wagon tongue, the corn is gathered from the ground or from the stack and elevated into the wagon. The illustration shows one of these

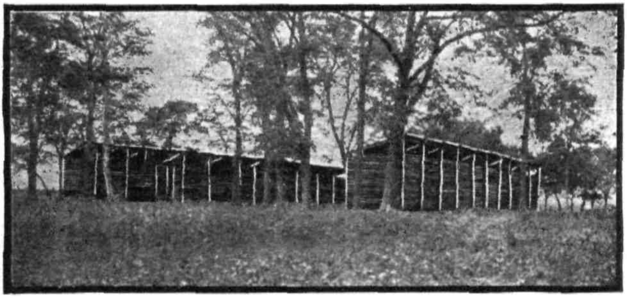


Fig 45—Rail Corn Cribs

In McLean county, Illinois

coils uncovered. The ears are conveyed to husker rolls in the front part of the wagon bed, where the husks are removed and by means of a blower transferred through a blowpipe to a burlap bag in the rear, large enough for holding the husks from one load of ears. The ears are deposited in the wagon bed. The machinery is comparatively light and can be handled easily by one team. The husker will fit any wagon box from thirty-two to thirty-six inches deep and weighs about seven hundred pounds. After another

season's testing, the machine will be put on the market provided it continues to give satisfaction. The inventor has been working on it for about fifteen years.

THE CRIBS TO USE

Suitable cribs are important where corn is to be held for feeding or for higher prices. The rather careless methods in vogue in many of the western states are to be discouraged. For instance, in many localities rail pens are used, especially for the surplus corn. These will fairly well answer the purpose provided they have good bottoms, are built well off the ground and are carefully covered as soon as filled. As a general rule they are left uncovered until some convenient season and very frequently heavy rains fall. In any event, the top layers are badly bleached and sometimes more seriously damaged, while occasionally the cribs "take water," resulting in rotten and moldy ears. Of course, most farmers have permanent covered cribs which are perfectly safe. These are somewhat more expensive than the temporary rail cribs, but when the corn is once in them there is little or no danger of its spoiling. The loss from rats and mice can be prevented to a certain extent by building cribs well off the ground, say eighteen to twenty inches, placing inverted tin pans on top of the pillars, or bands of flaring tin about them near the top.

The most satisfactory storage place for unshelled corn is the double crib with a covered passageway between. This is made of pine lumber. The frame is made of the usual sills, two by eight joists, two by four studding, two by four rafters, one by four boards for siding and the roof shingled or covered with iron roofing. The boards used for siding must be at least two inches apart so as to permit free circulation of air.

The corn is kept in these cribs until ready for use or for sale. If sold it may be hauled to the elevator in the ear, or, what is much better, is shelled at home where the cobs can be used as firewood and the grain more easily taken to market.

SHRINKAGE OF EAR CORN

The time to sell depends somewhat upon the amount of shrinkage from the time the corn is husked until it is sent to the elevator. This matter of shrinkage is not well understood, and varies greatly with the season, the character of the crop, the character of the crib in which it is stored, etc. A number of tests have been made by farmers and by experiment stations. At the Michigan experiment station in 1896 corn was husked October 3 to 5. By the middle of February the shrinkage amounted to thirty per cent. This was, of course, an extreme case. In another test at the same station corn was husked October 21 and shrank eleven per cent by January 31, while well-cured corn in Van Buren county, Michigan, shrank only three per cent from the time of husking until January 7. At the Iowa experiment station corn was placed in a crib set on scales and the decrease noted from month to month; this test was continued for three years. The first year the shrinkage was twenty per cent, the second year a shrinkage of only nine per cent was noted, and the third year fifteen and eight-tenths per cent. The average about fifteen per cent. At the Illinois experiment station one thousand bushels of corn lost eleven and one-half per cent from the time it was cut until it was thoroughly air dried. This is the result of a three years' test. A Tippecanoe county (Ohio) farmer placed nineteen thousand seven hundred and one pounds of white corn in a crib December 15, 1894. By August 16, 1895, it lost fifteen and one-half per cent.

In Christian county, Illinois, Messrs Ricks, Provine & Maxon placed sixteen thousand one hundred and fifty-five bushels of corn in an ordinary covered crib during the autumn of 1895. The corn was sold the following July, the shrinkage amounting to seven and three-fourths per cent. The corn was in fair cribbing condition when husked, but the winter and spring following were unusually dry.

In the fall of 1897 seven thousand one hundred and six bushels were cribbed, and sold in July, 1900, and the shrinkage was three hundred and fifty bushels, or slightly over four and nine-tenths per cent. In 1900

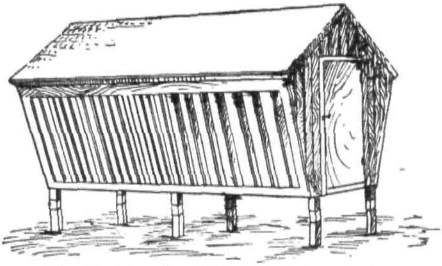


Fig 46—Excellent Rat-Proof Corn Crib

twelve thousand two hundred and twenty-eight bushels were cribbed, and the shrinkage by the next fall amounted to four hundred and fifty-three bushels, or slightly over three and seven-tenths per cent. Mr Maxon states that the corn in 1899 was very poor, in fact the poorest ever raised on that tract, but in 1900 the crop was of excellent quality, although the ears were not large. He believes that his neighbors consider his corn shrinkage very small. This may be due to his manner of cribbing it and to the quality of the corn. He has a double crib two hundred and fifty feet long which holds twenty thousand bushels. The corn is kept quite dry.

In 1881 Dr Manley Miles made some tests in Michigan and found that from husking time until the succeeding spring the shrinkage amounted to a little over fifteen per cent. In Kentucky a number of farmers pay particular attention to shrinkage and they find it ranges from seven to eighteen per cent. A number of tests have also been made by experiment stations to determine the amount of shrinkage after the corn has been shelled. In most of the tests shelled corn shrank seven and one-half per cent during five months.

THE LATEST IN CORN HARVESTING MACHINERY is the corn harvester and shocker. It consists of a corn binder in which the binding apparatus is replaced with a platform and windlass. The corn is cut but not bound. It collects on the platform until a shock of the desired size is secured. The machine is then stopped, the shock tied by hand, the windlass ropes adjusted and the shock deposited on the ground in an upright position. The shocks are necessarily small. This is a very satisfactory method of cutting corn where the corn is to be husked as soon as dry and the fodder put into larger shocks. If to be fed unhusked it is more economical to use the binder as the work can be done more rapidly.

CHAPTER XI

Culture Outside the Corn Belt

ESSENTIAL variation from northern and western custom over probably four-fifths of the corn planting area of the south is twofold: In mode of planting and in method of harvesting. The one naturally follows more or less upon the heels of the other, although events have recently proved that the practice of harvesting may be made, to a great extent, independent of both the system pursued in planting and of intercultural methods.

SOUTHERN METHODS AND PRACTICES

In plan is noted the first important divergence: wide rows and a reduction of stand, generally to one stalk per hill. This method obtains largely in all upland planting from the Virginia and Tennessee lines southward, and a departure therefrom is a distinct exception. Even in these states there are portions where the southern method is exclusively followed, particularly in the Freestone districts; and, per contra, farther south there are regions, especially in western North Carolina, northwest Georgia and north Alabama, where the northern system has always been practiced.

Spacing, both as to row and hill, greatly varies. The thinner and poorer the soil the wider the rows are stretched, until a maximum of six feet (rarely six and one-half or seven) is attained in the sandy pine barrens or on the red-galled uplands of the middle south. Three feet apart in the row is generally the distance

fixed for the hills, though this, too, sometimes varies. The range covered will be found about as follows: Six by three, maximum; five by three to four and one-half by three, average; four by four, occasionally; four by three (extending in rare instances to four by two and one-half), minimum. Without the precaution of carefully gauging the capacity of each separate land area and fixing his distances for planting to correspond, the southern corn grower is liable to invite serious disaster.

There must be noted, in explanation of the original cause for this deviation from accepted method, two things: First, that the cornstalk at the south (by reason of the difference in selected varieties and also from climatic and morphological causes) is much larger and more robust than that at the north on the same grade of soil or in proportion to yield of grain; and second, that at the critical period of pollination there is always a want of soil moisture to be feared, since the rainfall at the south is more variable. Consequently, land that at the north would sustain and profitably fruit say seven thousand two hundred and eighty stalks to the acre, would at the south be taxed to the utmost to successfully develop half that number. Yet the gross weight of the stover from both acres would be, perhaps, practically the same, although the southern plat, fertility being equal, would yield a lower return in grain, an unavoidable inequality which nature has somehow seen fit to impose.

For bottom land of course much greater crowding than that scheduled for upland is permissible, and invariably utilized—soil conditions more nearly paralleling those of the great corn areas of the west. The rows are seldom or never contracted to less than four feet, but the hills vary from one and one-half to two feet, and will sometimes, at the latter distance, contain

two stalks. Occasionally rich upland admits of the same treatment as that practiced with bottoms.

Regarding methods, there is one distinctive feature of difference to be marked in certain sections where planting in the water furrow is followed. Ordinarily, the land is broken, and with the careful cultivator harrowed or fined, and the rows, whatever the distance, are run out with a shovel plow, on the level, fertilizer distributed, and mixed with a scooter furrow, and the corn planted therein, either with a dropper or by hand. But in the peculiar practice referred to the land is generally broken by bedding to the center—to every other row in three feet cotton land, or to the old furrow in corn land. This leaves a deep water furrow in the new middle. In this water furrow the corn is planted and the soil gradually worked back during cultivation, leaving the surface again practically level, to insure sufficient moisture for the roots. The plan is sometimes reversed on very flat, poorly drained land, and the corn planted on the bed thus formed.

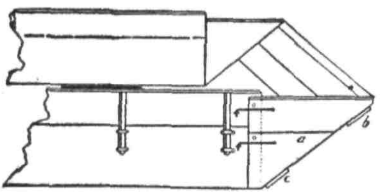


Fig 47—Wagon Box Attachment

For ease in unloading corn, the device here illustrated may be readily made and attached to rear end of wagon box so that shoveling may begin at once upon reaching the crib. Make a sloping floor, *a*, a few feet long, with crosspieces on the lower side at *b* and *c*. This floor is as wide as the outside of the wagon box. Then pnt on short sides nailed securely to this sloping floor, and extending forward a few inches past the sides of the box and on the outside of it. Take out the end gate and gate rods and put on this attachment, securing it in place with four bolts. The lower crosspiece, *c*, should extend out a little beyond the wagon bed on each side and come down against it, the sloping floor resting on the bottom of the bed an inch or two from the back end. The attachment can also be fastened with stout hooks and staples.

The Dunton system, originated by a progressive farmer, H. J. Dunton of Smyrna, Georgia, has met with varying favor and success in different localities. The

originator has followed it for years and practically illustrates its efficiency. The system consists in first determining the capacity of the land as to spacing, which may be found for a given locality, let us say, five by three feet, one stalk to the hill. The hills, by Dunton's method, are then located double that distance apart, or six feet in the row, but two stalks are left in the hill, instead of one. The claim is advanced that a maximum yield is thereby rendered more certain, on the theory that the root system of a hill, on reaching out laterally for plant food in all directions, soon interlaces with that of its neighbor, where the hills are spaced a short distance, as three feet apart; and, as the fertilizer* is distributed in a continuous stream down the row, the foraging capillaries would by earing time have exhausted the available supply. Were the hills spaced six feet apart, the roots, having to travel twice as far, would not have drained the entire reservoir of plant food at this critical period, and the plant would therefore have a surplus upon which to draw when most needed. Two stalks are left in each hill to equalize the total yield by giving the plat the maximum number it can profitably sustain under the calculated spacing of five by three, which at five by six would evidently be reduced by one-half with only one stalk to the hill.

The theory seems plausible enough, and is strenuously upheld by those who practice it; but it must be admitted that the results of careful tests at the Georgia experiment station do not justify it, and tend to confirm the original (and general) theory that the more nearly the individual plants are equidistant from adjacent plants, the better the result.

*Commercial fertilizer, of course; the theory would not obtain where the land was improved and the soil was uniformly fertile in every portion, but only where the crop depended on an annually received supply.

The double row or alternating method of spacing has occasionally been successfully employed at the south, the hills being spaced on either side of the manured furrow, three or four feet apart from each other, on the same side of the row, and so alternating as to reduce the diagonal line between them to half that distance. The rows vary in width from six to seven feet from center to center. A row of cowpeas always occupies the middles. This method of spacing has never particularly commended itself.

The Cowpea in Corn Land—The cowpea is, at the south, the inseparable companion of the corn plant, and altogether the most valuable legume for restorative purposes known to the agriculturist of any land. It is planted either in the middles between the corn rows and cultivated with the crop; dropped alternately with the corn between the hills, or sown broadcast on laying by. It thus serves the double purpose of furnishing its quota of valuable food material at harvest time, either in peas or vines, and of economically improving the soil—physically, by the organic matter which its structure supplies, and chemically, by the enormous store of nitrogen fixed by its root system.

But the most important function or servitude of the cowpea consists in the part it plays in the now well recognized triennial rotation system, by means of which southern agriculture is gradually being elevated to a higher and more remunerative plane. Under this system corn is made to follow cotton, small grain (oats or wheat) to succeed corn, and after the grain is harvested in June the area is broadcast with cowpeas, which are cut in September and converted into either hay or silage, the stubble only remaining to accomplish the work of renovation. This, however, it does so effectually that thereby an amount of organic matter and potential nitrogen is supplied, acquired after ninety

days' growth from the seed, greater in quantity and value than that contributed by a two-year-old clover crop at the north. It is therefore not surprising that the cowpea should be regarded as the sheet anchor of the southern farmer. Indeed it is due in great measure to the impression that the northern plan of harvesting corn would largely interfere with the accompanying cowpea crop that the system has been so slow in commending itself to the southern planter.

HARVESTING IN THE SOUTH

The Old Way—Supposedly necessitated by the differing climatic conditions of the sections, it was generally deemed impossible, until definitely proved otherwise, to harvest the southern corn crop in the northern manner: First, because it was thought that their earlier maturity forced the harvesting of the blades (technically "fodder" at the south) if utilized at all, as an additional and separate operation to the subsequent "shocking" process, since the hotter suns were presumed to parch them prematurely. No one for a moment entertained the idea that the entire stalk could be cut and cured soon enough to preserve the nutritive value of the blades without ruinous loss from the shrinkage of the grain in the ear. Secondly, if the blades were stripped separately and the naked stalk and ear left, there was no temptation in the stalk itself, valueless before the advent of the shredder, on account of its size and coarseness, to induce its preservation. Thirdly, because the southern stalks were presumed to be too large and succulent to respond without injurious fermentation to the curing process. Hence originated the three following primary differences in practice under the old system.

1. In saving fodder, details consist in stripping, by hand, the entire stalk of its blades on their maturity; that is, at as late a date as possible consistent with the prevention of the firing or parching of the blades themselves, in order to utilize their function as foliage to the last moment, and prevent subsequent shrinking of the grain on the ear. Fodder pulling is effected, according to latitude and season, from the first of August to the middle or even the last of September. When the operator's hands are full of blades and he can hold no more the quantity is termed a "hand," and is bound rapidly with a twist and hung on a broken stalk to cure. On gathering a day or so later, from three to four hands, usually four, form a "bundle," which is also bound with a few twisted blades. The bundle weighs from one and three-fourths to two pounds, and forms the staple "roughage" of southern draft stock. There is nothing, indeed, more palatable or wholesome and little that is more nutritious. Its necessary cost is its chief objection.

2. Stripping the lower stalk to the ear, or to the first ear, if more than one, and leaving the blades on the upper stalk intact to complete the development of the grain, is another practice. Of course, much material is thereby lost, and as has been recently proved, without adequate return unless the ear is at the time abnormally immature.

3. Stripping the lower stalk as before but cutting off the upper stalk and shocking the tips, until cured, for rough cattle feed, was practiced largely. This is more logical and rational.

In handling, the ear left in the field pendent, in situ, from the stalk, until fully mature, under improvident management or inferior market facilities, is frequently "slip-shucked" and carted to barn or crib. More thrifty husbandry pulls shuck and all. In either

case the corn is generally stored in the shuck, contrary, of course, to the northern and western custom, and husked as needed for daily consumption, or, as in ante-bellum days, in the periodical and picturesque "corn shuckings" of song and story. These, however, are almost traditionary. The times have changed and more practical, if less romantic conditions prevail.

What forms under the new practice the great bulk of the conserved stover, was, and under old methods still is, lost, except for the casual benefit yielded to the soil by its gradually decomposing organic matter. Left standing in the field it was (at best) in preparation for the ensuing crop, threshed down and turned under on breaking the land. More commonly, however, haste and improvidence prevail, and the stalks are wind-rowed or piled, and burned incontinently, only their mineral content of plant food availing a return, and even that irregularly distributed or concentrated in the ash pile. Surely there can exist no vestige of regret that at length the southern public has awakened from its lethargy and is now keenly alive to the fact that there is a saving alternative.

The New Way—Light out of darkness is due to the advent of the corn shredder. Its mission has just begun, but the beginning is good and its future progress will be sweeping, complete, triumphant. It is impossible, whatever the connection, to ignore the value of the shredder, the part it bears and the work it is doing, and has to do, as a factor in the progress and advancement of southern agriculture.

While the silo has accomplished much, the shredder is destined to effect even more. Its importance cannot be overestimated, for it is revolutionizing quietly, but effectually, an enormous industry in a dozen commonwealths. What it means in one state, alone, of the twelve, and for one season, let the following statement

of Director R. J. Redding, of the Georgia experiment station, attest: After showing (in bulletin 39) the average proportion of shredded corn hay to the bushel of grain to be ninety pounds, and of naked stalks about forty-two pounds, or twenty-eight hundred pounds of corn hay (of which thirteen hundred pounds is supplied by the stalks) to every thirty-one bushels of grain, the average yield per acre of the particular crop tested, Director Redding says:

> "This 1300 pounds represents the food loss for every 31 bushels of shelled corn. The corn crop of Georgia, for convenience, may be stated at 31,000,000 bushels, sometimes less, often more. Then, at 1300 pounds of corn hay, heretofore not saved, for every 31 bushels of corn, the total loss in the state would be $1300 \times 1,000,000 = 1,300,000,000$ (thirteen hundred millions of pounds), or 650,000 tons of corn hay. This is a very good food and worth at least $10 a ton, or a total of $6,500,000. This is about enough to pay for all the commercial fertilizers used in Georgia in one year. This may be considered a remarkable statement, and it will no doubt surprise many a farmer who has not thought about it and who has, perhaps, imagined that he has been very saving and economical."

Elsewhere he states that this saving would be equivalent to a rise in price of over six dollars per bale for the entire cotton crop of the state, or would furnish each head of draft stock and every milch cow in Georgia more than six pounds of good provender per day for the entire year. All this for one state, only; when extended to include the entire south, the aggregate becomes, indeed, enormous. Fortunately the lesson these figures carry is now being earnestly and enthusiastically taught—aptly and thankfully received. Reawakened hope has induced renewed energy and effort, and the result will soon be made apparent by the visibly increased thrift and prosperity of the entire section.

Many workers are contributing diligently, intelligently and successfully to the mission of the shredder, and each deserves his meed of praise, not only for what

he is doing, but for what he has done. Yet to Director Redding, if to anyone, should be given the chief credit for the initial steps leading to the present active metamorphosis in corn culture at the south. The Georgia experiment station first practically established the value of the shredder and exploited its principal product, corn hay, by proving incontestably that the anticipated and dreaded shrinkage of grain upon the ear was a mere phantom of the imagination, amounting at most, to some two bushels per acre in a yield of thirty-odd, with a consequent loss of one dollar, offset by a gain of more than six dollars in the stalks alone, exclusive of the saving resulting from the substitution of the new for the old way in the manipulation of the blades and shocks—certainly some four dollars additional per acre. The Georgia station and its director must also be credited with the chief part in exploiting the "triennial rotation system," and impressing its importance upon the public.

The large size of the stalk in southern varieties of corn necessitates a difference of procedure from the northern method in one detail—shocking. It forces the employment of the "grasshopper," a light wooden frame, some five feet high, like a capital A, with one or two more cross-slats. From the apex of the A extends an eight-foot scantling diagonally to the ground. This simple apparatus, moved about the field by the shockers, materially assists the process of bunching and binding, the workmen mounting it to arrange and tie the stalks.

One Acre Yielded 255 Bushels—In considering southern methods of growing corn it is interesting to note briefly the record of Z. J. Drake of Marlborough County, South Carolina, who produced the grand prize crop in the *American Agriculturist* contest conducted in 1889. From a single acre Mr Drake grew two hun-

dred and fifty-five bushels shelled corn, or two hundred and thirty-nine bushels crib cured corn.

Late in February one thousand bushels stable manure and five hundred pounds each of manipulated guano, cottonseed meal and kainit were broadcasted on the acre and then plowed under. Following the plow six hundred bushels whole cottonseed were strewn in the furrows. A subsoil plow was run through a depth of twelve inches. The land was well harrowed and the rows planted alternately March 2, three and six feet apart. An improved strain of the common Gourd variety of southern white dent corn was planted, five or six kernels being dropped to each foot of the row. It was planted in the rows five inches deep but covered only one inch. At the first hoeing the plants were thinned to one stalk every five or six inches, the missing spots replanted. On April 20 the six-foot spaces were plowed and a mixture composed of two hundred pounds each guano, kainit, cottonseed meal, acid phosphate and bone was applied and hoed in. On May 15 the three-foot spaces were plowed, three hundred pounds nitrate soda sown and worked in. On May 25 two hundred pounds guano were applied in the wide spaces. Another application of five hundred pounds guano, cottonseed meal and kainit was put on June 8, and one hundred pounds nitrate soda June 11. The crop was harvested November 25, before several reputable witnesses. It yielded seventeen thousand four hundred and seven pounds of corn in the ear, of which one hundred and forty pounds was soft corn. Several tests showed that one hundred pounds ear corn yielded eighty-two pounds shelled corn, which made the yield two hundred and fifty-four bushels forty-nine pounds of shelled corn at fifty-six pounds to the bushel, which, kiln-dried, to contain only ten per cent water, would contain two hundred and thirty-nine bushels.

CULTURE IN NEW ENGLAND AND THE EAST GENERALLY

New England offers varied conditions for the growth of the corn crop. In the most northern portions of Vermont, New Hampshire, and central Maine, there are but ninety to one hundred days free from frost, so that only the earliest maturing kinds of flint corn can be successfully grown. In the southern portion with one hundred to one hundred and twenty-five days free from frost, there is no trouble in maturing all of the flint varieties and many of the dent sorts. Owing to the great expense formerly attached to growing corn by the old hand methods,, this crop fell somewhat into disrepute and the drift of agricultural opinion from 1865 to 1875, or later, was that this crop could not be grown with profit, either because of the cheaply produced and transported western product, or because of the demand of our markets for supplies in producing which the west could not compete. Therefore, it was considered a stroke of good policy to grow the other products and buy the corn needed for home consumption. Since 1875, this opinion has been materially modified until it is now generally conceded that corn is one of the most profitable crops farmers can produce.

Returning Favor for Field Corn—Silage methods had made the fodder part of the crop so valuable as to pay the cost of cultivation, while at the west it had little value. The rough and rugged character of most of New England farm land precludes the economical use of the methods and machinery employed in the corn belt. Small farms, small fields, short rows, a thin soil often filled with loose and fast stones makes it impracticable to use two-horse cultivators and planters. The old time method of planting by hand and covering

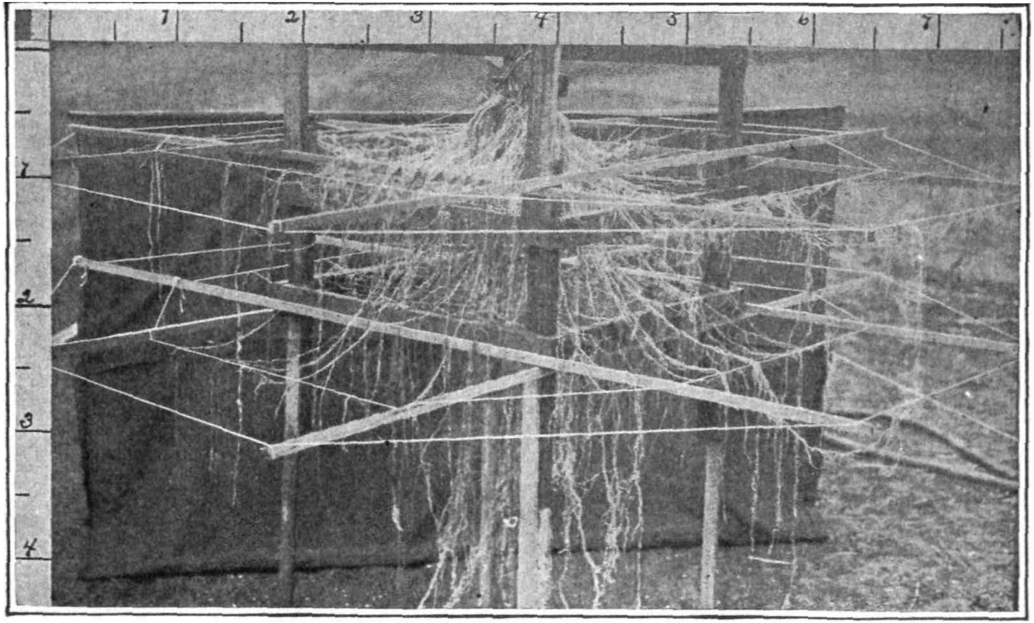


Fig 48—Root Development of a Corn Plant
Just beginning to tassel. See Chapter VIII

with a hoe, as well as of hoeing the corn and plowing it, has gone by, and in its place have come the hand and one-horse planter, the weeder and one-horse cultivator.

The heavy crops, some .wo hundred bushels ears per acre, are generally grown upon the inverted sod of mowing fields. Good corn, although not so many bushels per acre, is produced upon old, wornout pasture land. This land is best and most economically prepared by the cut and cover system of plowing any time during the summer. If time will be valuable the following spring, harrow down the furrows in October and crossplow in a dressing of good manure. If the manure cannot be afforded, then simply crossplow and in the spring use half a ton per acre of superphosphite, sowing about six hundred pounds, to be harrowed in, and put the balance in drill. With this outlay and good cultivation, from one hundred and thirty to one hundred and forty bushels ears and about two and one-half tons fodder per acre can be secured. If manured in the fall, harrow down well the following spring and a little phosphate in the drill will give about the same result.

Early Growth Best in the East—The corn plant secures its growth during the first portion of the season; the latter portion of the season being utilized in maturing the crop. The seed bed should be so prepared as to secure the maximum fertility, moisture and temperature in conjunction, hence shallow plowing is usually followed as leaving the most fertile portions near the surface where the rains penetrate and where the sun exerts the greatest power. The depth of plowing will vary with the soil and the season, but an average depth of about five inches is usually followed for spring plowing.

The best soil for corn is a strong, sandy loam or an alluvial soil, but it can be grown successfully on any soil where water does not stand between its particles within eight or ten inches of the surface.

Most New England soils, especially those of clayey formation, can be handled better in the fall than in the spring. It gives the air and frost a longer time to work on the particles; in other words, there is a longer time for unavailable plant food to be changed into the available form. Gravelly soils and those that leach easily by rains, perhaps can better be plowed in the spring. They dry off readily and planting is never materially delayed. When the soil is dry in spring the disk and spring-tooth harrows should be used, but do not hurry. It will take another freeze to remedy the evil done by plowing or harrowing a wet soil. Soil that has been plowed in the fall is usually compacted and hardened by spring. In this case replowing is advisable.

PLANTING AND CULTIVATING

The harrowing should be thorough and should follow the plowing, precede the application of manure and fertilizer and again follow the application of the fertilizer elements. On sod ground, a disk or cutaway harrow does by far the best work.

Corn is called a gross feeder and responds quickly to heavy feeding if the elements are presented in soluble form. Best results are obtained by broadcasting the fertilizer or manure after plowing and harrowing in thoroughly, but probably the majority of farmers still follow the practice of drawing out the manure and spreading it before plowing. On lands which are subject to washing, the manure should be incorporated with the soil as quickly as possible after being put on. The amount used per acre varies greatly with character

of the soil and the quantity available. Five cords of good yard manure per acre are sufficient, or six hundred to eight hundred pounds fertilizer. The quantity used, however, is governed by individual circumstances. For bringing up thin and wornout soils, cowpeas or clovers may be used with advantage. These precede the corn crop. The cowpeas are plowed under in the fall and the clovers in the spring and chemical fertilizer is used with them.

In planting, both the checkrow and drill systems are followed, the latter giving slightly the best yield on soils not too weedy. This method is also used largely where the crop is grown for fodder or for the silo. The checkrow system allows of cultivation both ways, and is almost invariably followed where the crop is grown for the grain. The rows vary in width from three to three and one-half and occasionally four feet, depending somewhat upon the variety and strength of the soil, the greater distance being used on thin soils and in large-growing kinds. Where corn is planted in drills the rows are commonly three and one-half feet and the kernels dropped from six inches to one foot in the row, although for fodder purposes it is planted thicker, yet great caution should be used that when in full growth it is not so thick as to shut out the free circulation of the air and the penetration of sunlight to the great mass of the stalks and leaves. Horse corn drills are much used and recommended because they distribute fertilizer in the row at the same time of dropuing the seed. This gives the corn a quick start and pushes it along during the early part of the season. Early planting is of great advantage, but the exact time of planting can only be governed by the neighborhood and the season. The middle of May in most seasons for southern New England is about right.

The object of cultivation is threefold, viz, for till-

age, to conserve moisture and to kill weeds. Many farmers, here as well as elsewhere, lose sight of the first two objects and cultivate merely to keep down the weeds. Soon after the corn is planted, and before it comes up, the fine steel-tooth weeder, a smoothing or straight-tooth spike harrow, is run over the field to break up the crust which may have formed and to kill the young weeds. This operation is repeated at intervals of a week until the corn is six to eight inches high, when the one-horse cultivator is commonly employed. If used frequently and before the weeds have taken strong foothold, the weeder is the cheapest and most thorough implement for cultivation in use at the present day.

The hoe is seldom used by progressive farmers, except occasionally in small portions of the field which are very weedy. The one-horse cultivator, and, on some large farms, the two-horse spreading cultivator, is run through the corn both ways from two to four times until the corn reaches nearly to the horse's back. At the last cultivation, side wings are often put on the cultivator and a slight hilling given to cover up any weeds between the rows which may have escaped the cultivator.

Some farmers make a practice of seeding grass in standing corn and are quite successful in obtaining a good stand. The last cultivation is level and then timothy and redtop are sown by hand or with a seed sower. The seed is raked in either by hand with a broad rake or by the use of a fine-tooth cultivator. The corn is cut low and the stubble rolled in the spring so as to give no interference to the mowing machine. Crimson clover is also usually sown before the last cultivation to plow under the next year as a green manure. The depth to which the cultivator is run should vary with the season and the soil. A good rule is to cultivate deeply in a

wet season in order to dry out the land as much as possible. In a drouth, cultivate shallow to secure a fine surface mulch.

HARVESTING AND CURING

The advent of the corn harvester, which cuts and binds the corn into small bundles at one operation, is working a revolution in the methods of harvesting corn. The harvester can be worked successfully on most rolling fields not too steep for mowers, reapers or other harvesting machinery. If the corn is to be put in the silo, the bundles are loaded onto wagons and drawn to the cutter. If the corn is to be cured and husked, the bundles are carried together and set up in large shocks or "stooks," as commonly known in New England, being tied at the top with a stout twine or braid of straw. Where the harvester is not employed, harvesting is commonly done by two methods. Upon this subject, Professor Levi Stockbridge, ex-president of the Massachusetts agricultural college and an eminent authority, says:

"Harvest by cutting the fodder with the ears upon it, and secure the whole from injury by placing it in compact stooks. It will cure sound and hard in average seasons if it is harvested with the stalk, when it is getting out of the milk, and the outer end of the kernel is beginning to glaze. As all the ears of a field will not be in the same condition at any given time, harvest when an average shows a surface too hard to be easily indented with the thumb nail; but at the same time regard must be had to the condition of the stalk and leaf, and the season.

"Whether ripe or green, it should be secured in the stook before frost. The grain will not perfect itself after the leaves and stalks have been frozen; and the fodder is nearly worthless. When the leaves and stalks have changed their dark green to a straw color, the lower leaves and the tops of some of the upper ones will have begun to shrivel, the whole crop is in a condition to harvest with the greatest profit. The precise method pursued in harvesting will be determined somewhat by the after-use which is to be made of the land, and the character of the help employed. If the field is to be sown to winter

grain, and before the husking of corn and the removal of the stooks, the following method will be the easiest and quickest: Determine by the rows of corn the line on which the first row of stooks shall be placed, and then cut four rows of corn and lay them in one row of bundles of a size which a man can handle without extreme effort; then on either side of the row of bundles cut four more rows of corn in the same manner, but lay them on the ground with the butts of the stalks toward the row first laid down.

"Rye straw is the best material for binding these bundles, which should be done just as near the ears as possible; and, while the workman has the bundle in his hands, he should turn it over endwise, without lifting it, so that its tip lies where he can reach it and set it into the stook without any carrying. Proceed in this manner, putting twelve rows of corn and three rows of bundles into one row of stooks, until the field is finished. This method will leave wide spaces between the stooks for plowing and sowing; and the strip on which the corn stands can be plowed afterward, which is preferable, if the crop is early. In cases where the corn land is not wanted for sowing, another method may be adopted, which avoids much hard labor, and secures the crop with greater dispatch, as follows:

"Select the corn row on which the first row of stooks is to be placed, and bend over two hills of corn at the ears, and tie the tops together by turning them over each other in a half-knot; then cut two or four rows on each side of this, and without laying them on the ground, stand them, handful by handful, in a bracing position, evenly about the two hills which have been tied together. Proceed in this manner until the whole field is completed. In heavy corn it is sufficient to put five rows into one row of stooks. A two-legged 'wooden horse' is sometimes used to support the corn as it is cut; but in some respects it is not as good as the tied corn hills. In both these methods of harvesting, the stooks should be no larger than is necessary to enable them to stand firmly; should be so arranged as to permit a free passage of wind through them from the ears to the ground; and should have their tops turned over, and be securely bound so low as to strengthen and support them.

"The grain will usually be ready for the bin when the leaves are dry, and the stalks dry for half the distance between the ears and ground. If the 'stub' stalks are quite dry, or contain visible juice, they will do no harm in the stack or mow, if the upper stalks and leaves are well dried. The method of husking must be governed somewhat by the weather, the floor-room in the barn for doing the work, and whether it is desired to save the husks separate from the rest of the fodder. The main thing in the process is to utilize time, and save expense, by handling the stalks as little as possible. This will be ac-

complished by picking the ears from the stalks in the fields, to be husked afterward, and then to cart the stalks directly to the storage room. Husking in the fields, with average hands, is objectionable, and more or less of the fodder will be wasted."

Old Methods Displaced—The old method called "top stalking," which was practiced by our forefathers and the Indians, is but little followed to-day. Theoretically it consists of cutting off the sterile stalks at the ground and the fertile ones smoothly at the junction of the ear, when the stalks and leaves are quite green, and the grain just commencing to harden; but practically it is the cutting off of the top stalks, with one clean sweep at each hill, near the top of the highest ears. The remainder of the stalks, with the ears, are then allowed to stand in the field until they become dry, sear and dead. Then the ears are husked on the hill, or picked and stored in some building convenient to the corn crib, and husked as opportunity offers.

The fodder remaining in the field after taking off the corn is sometimes cut at the ground, and taken to the barn for feeding the stock; but generally the stock are turned into the field in the bleak days of November and December, to pick off some of the dry leaves and husks, and to trample down the remainder preparatory to plowing it into the soil. This method is too wasteful for the practical farmer. More nutriment is contained below the ear than above it, and practically all of this is waste so far as its feeding value is concerned. The hot sun dries instead of ripens the ears and neither the quality nor the yield of corn is as good as where it is allowed to ripen naturally.

CORN GROWING UNDER IRRIGATION

Aside from irrigation itself, the general features of corn culture under irrigation do not differ materially

from those required for the best results in a humid climate. For nearly all of the irrigated region, fall plowing is preferred, not only because it gives a better opportunity for weathering and disintegration during the winter, but also because the soil particles have an opportunity to settle together and pack sufficiently for quick capillary attraction and to prevent too free circulation of the air to deprive it of moisture. The spring plowing is too loose and open for best results, giving it an opportunity to dry out too fast, and leaving insufficient moisture for germinating the seed. The deep plowing is also desirable to afford a reservoir to hold the winter and spring precipitation, and increase the depth to which roots may readily penetrate for food and moisture.

The same early surface cultivation in the spring is as desirable as in other methods of corn growing to destroy the weeds just as soon as they have started, and to establish a soil mulch to prevent the loss of moisture by evaporation. The same rules govern as to the time of planting, that is, when the season is advanced sufficiently to warm up the soil enough to start the seed promptly after it is put into the ground. For irrigation, the land needs some additional preparation. The field should be graded to an even slope in order that the water may pass freely over it. Knolls and ridges must be leveled down, holes and depressions filled up and dead furrows eliminated. The frequent cultivation with a harrow or a weeder from the time of planting until the corn is too large for this method of tillage is essential also to kill the weeds, to renew the soil mulch and to keep the land in a proper condition of tilth.

Irrigation—Irrigation should be deferred until the corn shows the need of it. This is usually determined by its very dark color, or by its wilting slightly

during the middle of the day, showing that the evaporation more than balances the supply of water reaching the roots by contact or capillarity. The delay of the first irrigation serves a good purpose in causing the roots to extend downward to seek moisture and so start the growth in the right direction to prepare the plant for any lack of moisture that may occur. Early irrigation tends to make the plant shallow instead of deep-rooted, the direction of the roots being parallel with the surface or at a slight angle to it. Any after-extension caused by a short supply of water in this case is not nearly as effective as when the roots are already pointed downward, directly toward the moist soil.

Flooding and Furrow—Corn may be irrigated either by the furrow or by the flooding method. By the former the water is confined to furrows running near the rows or midway between them, and passes through until the soil is made wet by capillarity. By the latter method the water is distributed over the field from head ditches and laterals the same as for small grain crops. Farmers are divided in opinion as to which of these methods is better. Though a large majority of them follow the former, there are many points favorable to the latter. By flooding the work is more quickly done and less labor is required to prepare for it. The soil takes up more water and is more thoroughly and evenly saturated, and because of the extra moisture taken, in many localities one irrigation is saved during the season. Those who have followed the flooding method claim that no harm comes from it, if the irrigation is followed by cultivation as soon as the ground is dry enough to be worked to prevent baking, and this precaution is necessary, too, even in the furrow method.

Soils differ so much in their texture and tendency to puddle and bake that neither method can be recom-

mended as best in all cases. Soils of a very fine texture that puddle easily will, no doubt, give better results from the furrow method, while those of medium texture that are little inclined to puddle or bake may just as well be flooded and thus save the extra labor and expense in preparation and applying the water. If it should be necessary to irrigate while the corn is yet quite small, the furrow method should be followed, because any puddling or packing close around the plant at this time will check its growth and, perhaps, prevent its reaching full development. The last cultivation before flooding should be made in the direction that the water is expected to flow over the land, so that the lines left by the implement may assist in its passage.

When the furrow method is adopted, the intertillage is just the same as that for flooding until the crop is ready to be irrigated, then furrows are run, usually half way between the rows, by a single shovel plow sufficiently deep to permit the small stream of water to flow through without flooding the rows. By this method the moisture reaches the corn from the furrow through capillarity and is not apt to cause puddling or baking. It is presumed that the stream will be confined to the furrow, though on pieces of land that have not been carefully leveled and given head ditches at proper intervals, the furrows are likely to run over and flood large areas, and the portion of the field adjoining the head ditch is much more thoroughly saturated than that farthest away. When confined to the furrows much water is wasted unless provision is made to carry it on to another crop. The hilling system of cultivation must accompany the furrow method of irrigation, and this exposes more surface for evaporation, the ridges formed drying out rapidly.

The time required for thorough saturation varies greatly, depending upon the condition and texture of

the soil. In a slightly sandy loam, the work is accomplished in a brief period, but more and more time is required as the soil grows finer in texture or more clayey in composition. The first irrigation is sometimes performed by running small furrows near the corn rows. In such cases the soil is not all made wet and less water is required.

Frequency of Application—The frequency of irrigation depends principally upon the capacity of the soil and subsoil for holding water, the depth to which roots may penetrate, and the attention given to keeping up soil mulch and freeing the land of weeds. The method of preparing the soil for planting, that is, the depth of plowing and thoroughness in pulverizing, and the quantity of water applied at each irrigation, will also affect the frequency. A sandy loam with a gravelly subsoil is very much less retentive of water and will, hence, require more frequent irrigation than a slightly clay loam with a medium clay subsoil. The frequency is also affected by the number of windy days and the regularity of the sunshine. The more cloudy days and the less wind, the more slow the evaporation and the less frequent the irrigation.

As the corn advances in growth and shades the ground more and more, the evaporation is retarded and there is a longer interval between the times of applying the water. While enough moisture should be kept in the ground for rapid growth, there is no time that an abundant supply of water is more needed or will have better effect than during the period covering the time from the appearance of the silk and tassel until the ears are formed, filled, and fully grown.

Time to Apply—If the soil contains a medium amount of moisture at the time of planting, and it is carefully conserved, there will be no need of irrigating until the corn is well started. It is better to irrigate

before planting than too soon after the corn is up. The usual plan of having the ground alternately wet and dry gives the right conditions for rapid growth, since the excess of water passing off from the surface by evaporation brings the soluble food constituents near to the surface where they are within reach of the plant roots.

The soil should contain enough moisture at planting to germinate the seed and to give the plants a good start. Delay the first irrigation until need of it is definitely shown, so the roots will take the right direction and penetrate the soil to some distance. After irrigation is begun keep the crop moderately supplied until the silks and tassels appear, when it should have an abundance until the ears are filled, after which irrigation may cease.

Amount to Apply—The soil should be given all the water it will hold at each irrigation, but there is no standard, the amount depending upon the texture and other conditions. It will vary from a few inches to a foot. From one to two acre feet are required to mature a crop and it should be applied at intervals of from fifteen to twenty-five days, depending upon the location and the character and preparation of the soil.

CHAPTER XII

Feeding

IT is not possible within the limits of a single chapter to present a treatise on animal nutrition. No attempt is made to discuss the many interesting and important scientific principles which form the basis of the rational feeding of animals, beyond those problems which are intimately related to the proper and profitable utilization of the corn plant. In no case is it possible or indeed advisable to attempt to set down fixed rules or definite directions for the guidance of the feeder. Local and varying conditions with reference to the abundance, convenience and cheapness of certain classes of foodstuffs; the class, quality and value of the animal product sought to be produced; the convenience to market, etc, are important and usually determining factors to which it would be impossible to make a general adjustment of any set of fixed rules.

Corn is the great American stock food. No other plant compares with it in its wide and general distribution, in the ease, certainty and cheapness with which it may be produced; in the yield of valuable food material per acre; and in the close relation it bears to the development of the live stock interests of the country. Every state in the Union, excepting Arizona, Idaho and Nevada, is reported as growing corn commercially. Where corn is grown extensively, there the live stock interests are extensively developed and prosperous. A corn center is synonymous with a live stock center, and the geographical distribution of corn production is in a general way an index to the dis-

tribution of live stock. Eleven prominent corn states, producing something over seventy-five per cent of all the corn of the United States, produce practically sixty per cent of the horses, mules, cattle, hogs, milch cows and sheep of the country. From these states are drawn the chief supplies of well-finished beeves and hogs, and well-developed horses and mules. They are the feed yards of the nation. It is a significant fact also that in this territory are concentrated the great herds of blooded horses, cattle, hogs and sheep. A country pre-eminently adapted to corn growing is at once pre-eminently adapted to the production of a high class of live stock. Even the stockmen and dairymen on the high priced lands of the east find it profitable, indeed necessary, to make corn the basis of the rations for their stock.

CHEMICAL COMPOSITION OF CORN

In accompanying tables in Appendix will be found the average chemical composition of the grain, mill products, etc, of the different types of corn.

A more detailed study of the chemical composition of the corn kernel has been made by the New Jersey experiment station. One hundred grams of corn kernels were separated as nearly as possible into skin, germ, and starchy and hard portion, and the different parts analyzed, with the result shown below:

.'ERCENTAGE COMPOSITION OF DRY CORN KERNEL

	Proportion of parts	Ash	Protein	Fiber	Nitrogen free extract	Fat
Original kernel........	100.0	1.7	12.6	2.0	79.4	4.3
Skin	5.5	1.3	6.6	16.4	74.1	1.6
Germ	10.2	11.1	21.7	2.9	34.7	29 6
Starchy and hard parts	84.3	.7	12.2	.6	85.0	1.5

These results are of particular interest in connection with a study of the by-products of corn, such as the gluten feeds, germ meal, hominy chop, corn

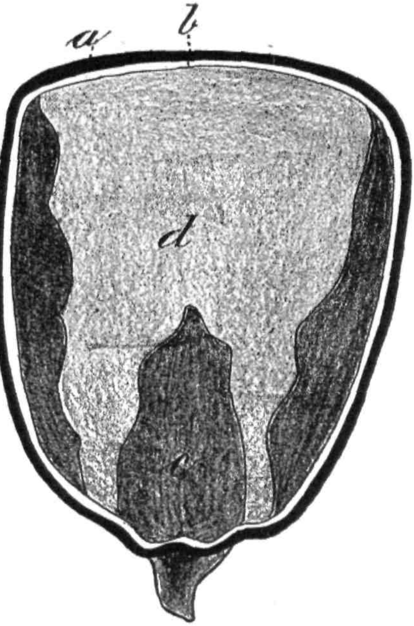


Fig 49—Characteristics of Kernel of Corn

a. The husk, or skin, which covers the whole kernel; it consists of two distinct layers, the outer and inner, which when removed constitute the bran and contain practically all of the crude fiber of the whole grain.

b. A layer of gluten cells, which lies immediately underneath the husk; it is yellow in color, and cannot be readily separated from the remainder of the kernel. This part is the richest of any in gluten.

c. The germ, which is readily distinguished by its position and form; it also contains gluten, though it is particularly rich in oil and mineral constituents.

d. The large portion, which is composed chiefly of starch; the dark color indicates the yellow, flinty part, in which the starch holding cells are more closely compacted.

bran, etc, resulting from the manufacture of starch, hominy, glucose, etc, from corn. These corn feeds

are now offered on the markets in such quantities as to be of considerable commercial importance and to be worthy of the careful study of the feeder.

The cut, Fig 49, which we are permitted to use through the courtesy of the New Jersey experiment station, will help the student to a clearer understanding of the particular parts of the corn kernel referred to in the tables above, and what parts enter chiefly into the composition of the different corn by-products now on the market.

It will be observed that the starchy portion constitutes more than four-fifths of the entire kernel, that the germ, which is only about one-tenth of the kernel, contains practically two-thirds of the fat and almost two-thirds of the ash of the entire kernel. The crude fiber is largely in the skin.

Most of the so-called corn feeds are what is left after the starch has been removed more or less completely from the grain. This is accomplished by mechanical means, and leaves the residue uninjured by the process, which in brief is as follows:

The grain is ground into meal, usually in warm running water or after it has been thoroughly soaked, and the various parts of the kernel named in the table are separated in water by gravity. The skin or hulls, forming the bran, float on the surface; the germs sink to the bottom, while the starch and hard portions of the kernel, carrying in addition to the starch a considerable portion of gluten cells, are held in suspension in the water. This water, carrying the starch and gluten in suspension, is then conducted slowly through long troughs, where the starch, being the heavier, settles to the bottom, and the gluten is carried on, to be recovered by evaporating the water.

The composition, therefore, of the by-product will depend upon the particular part of the kernel

from which it is made. When derived largely from the hulls, as in the case of bran, the content of crude fiber will be relatively high, and the content of protein and fat will be relatively low. If made from the germs, as in the case of the germ meals, it will run relatively high in fat and ash and moderately high in protein. The gluten as separated from the starch, when unmixed with other materials, is distinguished by its high protein content.

As found in the market, the principal brands are "sugar corn" or "starch" feed, made up mostly of hulls and germs; gluten meal, which comes from the flinty portion of the kernel; and gluten feed, which is now a mixture of hulls and the gluten part. When unmixed with other parts of the kernel, the hulls are also known as corn bran, and the germ portion from which the oil has been pressed is called, when ground, germ oil meal. The corn bran contains the least protein and the gluten meal the most, while the gluten feed and germ oil meal occupy a position between these. It should be remarked that the commercial names for gluten products are not always a safe guide in their purchase.*

All foods of this class, including such other by-products as wheat bran, wheat middlings, linseed meal, cottonseed meal, etc, should invariably be purchased on the basis of a guaranteed content of protein, fat, nitrogen free extract and fiber, just as commercial fertilizers are now purchased on a guaranteed content of nitrogen, potash and phosphoric acid.

DIGESTIBLE NUTRIENTS

While the tables to which reference is made, showing the amounts of the different classes of nutrients contained in the different varieties of corn, and the different parts of the plant, cannot fail to be interesting and instructive to the student of animal nutrition, at the same time it should be borne in mind that only a part of any vegetable food is digested by the

*Jordan—The Feeding of Animals.

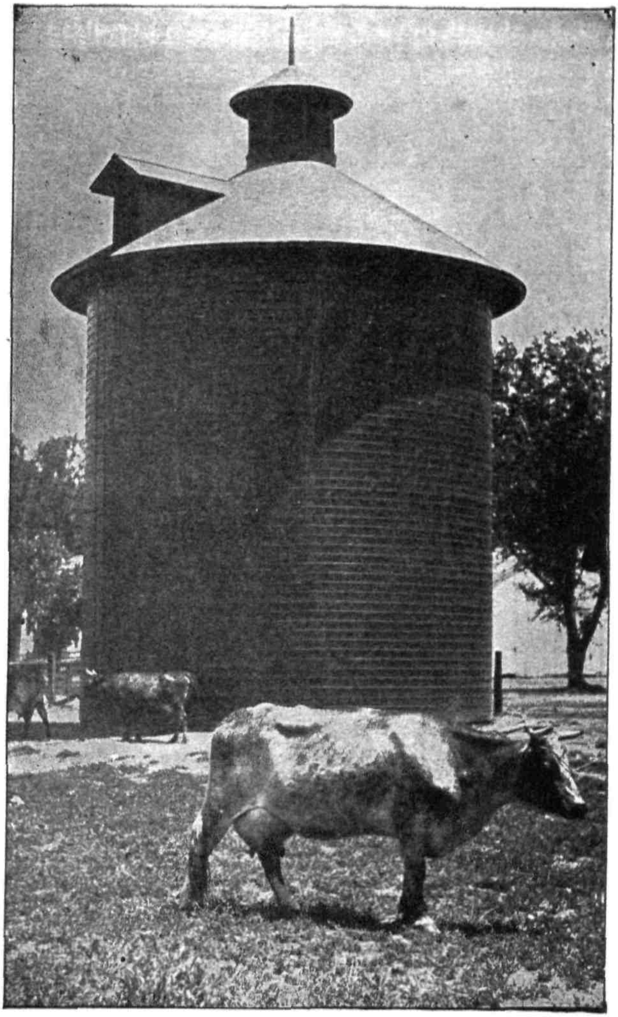


Fig 50—A California Silo Made with Studding

animal, the undigested portion being voided in the form of dung, as so much worthless or waste material.

In general the grains and concentrated feeds are more completely digested than the coarse fodders. A larger proportion of the corn grain is digested than of the corn stover. A larger proportion of wheat than of the straw. It is worthy of remark in passing that the corn grain is one of the most concentrated and is the most completely digested of any of the grain feeds. Then, too, the digestibility of any foodstuff may be affected within certain narrow limits by its palatability, by the quantity consumed by the animal, the stage of growth or development at which it was harvested, and its combination with other foodstuffs.

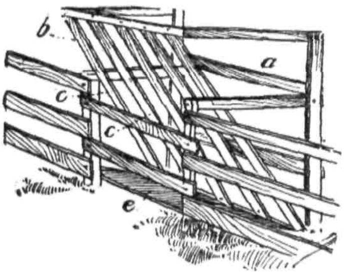


Fig 51—Rack for Fodder

In feeding unshredded corn fodder, care in handling may be secured through the use of the simple device here illustrated. This rack is easy to fill and will retain the stalks, allowing the cattle to eat off the leaves and other eatable portions The rack is to be built against a fence so that the filling can be done from the outside. The manger *a* is only high enough to retain the fodder Make the frame of 2x4's. The rack *b* should be made of four inch fencing lumber and slats about four inches apart. The outside rack *c* should be set out far enough so the cattle can reach down easily tc pick up the chaff The bottom *e* may be floored and this surrounded by a six-inch board to guard against waste.

Contrary to the general impression, the digestibility of a feed does not appear to be affected either favorably or unfavorably, at least to any appreciable degree under ordinary circumstances, by cooking, soaking, grinding, or the method of preserving or drying, so long as it is not subjected to mechanical loss of the finer parts in drying and handling or to molding or fermenting in the process of preserving.

The amount of digestible nutrients, therefore, is

a far safer measure of the feeding value of any substance than the chemical composition. For aside from its palatableness the value of a food depends first upon the amount of digestible material supplied, and second, upon the proportion of protein, carbohydrates and fat in this digestible material. To present this information concerning the products of the corn plant in a form convenient for reference, a table has been arranged, which may be found in the Appendix.

TO INCREASE THE VALUE OF CORN

The two most important ways in which the efficiency and value of the corn plant may be increased are: First, by supplementing the corn and stover with such foodstuffs are are relatively rich in protein, so as to furnish the animal a more nearly balanced ration than these materials alone supply. Second, by carefully saving and properly feeding the great crop of corn stover (the plant after the ears are removed) which now for the most part is allowed to go to waste in the great corn belt of the central west.

Corn Is a Carbonaceous Food—Notwithstanding the fact that corn is the best single stock food known and that thousands of animals are successfully wintered or fattened each year on an exclusive ration of corn and corn stover or some similar roughage, it is true that they are by no means a perfectly balanced or complete food. As has already been shown by the tables of composition and digestible nutrients, corn contains a very large quantity of carbonaceous matter in proportion to the protein compounds. It does not give a proper balance between the carbohydrates (which include starch, the sugars, fat, and digestible fiber) and the protein.

In other words, practical experience and scientific experiments have proved beyond doubt that by com-

bining corn with some feed that will increase the proportion of protein, a more efficient ration will be the result; more rapid gains will be made by the animals to which it is fed; more rapid and healthful growth will be made on young animals; a larger flow of milk will be obtained from the dairy cow, and the steer will carry a smoother finish and a finer coat to market; and, under ordinary circumstances, or if the material for balancing the corn be selected judiciously and with a due regard to the cost as compared with the increased efficiency obtained, an increased profit will be returned.

PARTIAL LIST OF FOODS RICH IN PROTEIN

	Percentage digestible nutrients		
	Protein	Carbohydrates	Fat
Corn (for comparison)	7.9	66.7	4.3
Corn stover (for comparison)	1.7	32.4	.7
Cottonseed meal	37.2	16.9	12.2
Linseed meal—old process	29.3	32.7	7.0
Linseed meal—new process	28.2	40.1	2.8
Glucose meal	30.3	35.3	14.5
Grano gluten	26.7	38.8	12.4
Gluten meal	25.8	43.3	11.0
Sugar meal	18.7	51.7	8.7
Wheat middlings	12.8	53.0	3.4
Wheat bran	12.2	39.2	2.7
Dark feeding flour	13.5	61.3	2.0
Buckwheat middlings	22.0	33.4	5.4
Oat feed or shorts	12.5	46.9	2.8
Malt sprouts—dried	18.6	37.1	1.7
Brewers' grain—dried	15.7	36.3	5.1
Soy bean grain	29.6	22.3	14.4
Horse bean	22.4	49.3	1.2
Cowpea grain	18.3	54.2	1.1
Field peas—grain	16.8	51.8	.7
Alfalfa hay	11.0	39.6	1.2
Cowpea hay	10.8	38.6	1.1
Crimson clover hay	10.5	34.9	1.2
Red clover hay	6.8	35.8	1.7
Skimmilk	3.0	4.9	.5
Buttermilk	3.9	4.0	1.1

FOODSTUFFS FOR BALANCING CORN

All stock feeds may be divided into two general classes—one in which the fat-producing and heat-

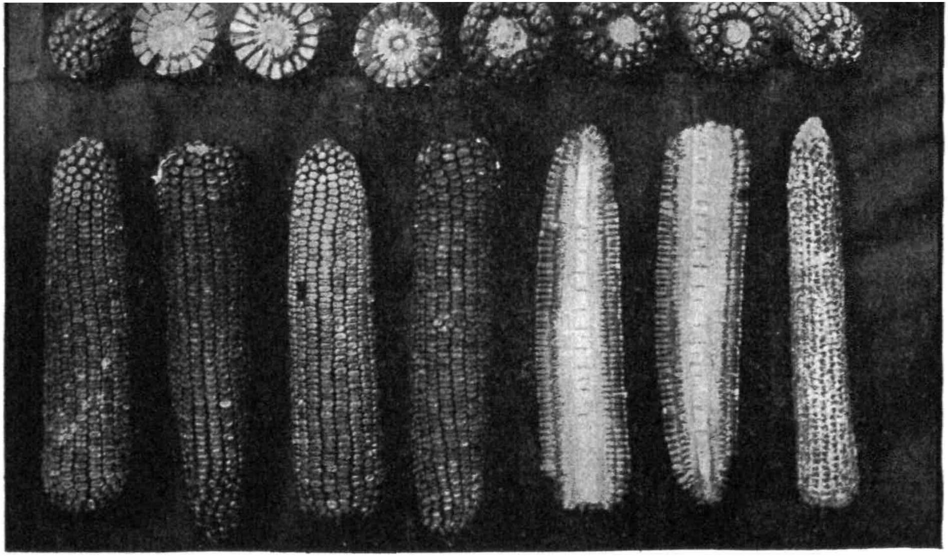


Fig 52—Leaming Corn Variety

This was grown by Mr J. H. Coolidge, of the Illinois seed corn breeders' association. This strain of Leaming was secured from Mr E. E. Chester, who carried the original Leaming from Ohio to Illinois. The sample shows that the undesirable characteristics of enlarged butt have been bred out by continued selection and breeding. See Chapter II.

forming ingredients, such as starch, the sugars, etc, designated as carbohydrates, and the fats, largely predominate; and the other class containing a relatively large amount of muscle-making material, commonly known as protein. This protein is required for good growth in young animals, and for breeding stock and animals in milk, and is very valuable even in the final fattening period. The line between these two classes of foods cannot be sharply drawn in all cases, some feeds being so nearly between the two as to be as appropriately placed in one class as the other.

As has already been pointed out, corn is the most important representative of the carbonaceous group, and we are here chiefly concerned in discovering the materials which may be used to supply the protein in which the corn is deficient.

The foregoing table contains some of the more important foods of this class, together with the digestible nutrients supplied by them.

Among those who have essayed to give advice on this subject are two classes of extremists. One unduly exalts the value of the nitrogenous group of nutrients and, by inference at least, insists that the ration must have a more or less definite proportion of protein in order to be adapted to a given purpose, even regardless of convenience or cost. The other, realizing the unsoundness of this extreme position, is unwilling to concede that any financial benefit will accrue from attempting to balance the ration to better meet the requirements of the class of animals to which it is to be fed.

It is not difficult to discover the absurdity of the position of the first class, when corn is worth, delivered to the railroad, from twenty to twenty-five cents per bushel, equivalent to seven to nine dollars per ton, and corn stover may be had in abundance for the labor of

cutting it, and the extra labor involved in husking the corn from the shock, amounting all told to not over one dollar and fifty cents per ton; again, when cottonseed meal or linseed meal costs from twenty to thirty dollars per ton. It is clear that it would be necessary for the balancing of the ration to exert a profound influence upon its efficiency in order to meet the increased cost involved. A study of the experimental results with balanced and unbalanced ration for different classes of stock which follows in this chapter, while showing a decided and uniform advantage in favor of the balanced ration, yet fails to show sufficient difference for most purposes to justify the expense in the particular case noted above. Clearly there is no law of nature or nations requiring the feeder to balance his rations beyond the point of profit.

On the other hand, if, as it will be clearly shown from the experimental data submitted, there is in nearly every situation an opportunity to so combine material at hand or material that may be gotten at a reasonable cost as to practically balance the ration and in so doing to increase the profits correspondingly, the conservatism and prejudice of the other class of extremists must at once yield.

In general, the best ration is made of such a combination of foodstuffs as will give the proper proportion of protein and carbohydrates for the particular class of animals or the special purpose for which it is to be used. At the same time careful attention must be given to the cost of the material to be used, the palatability of the ration and the convenience with which it may be obtained and fed. In short, the controlling factor in making up every ration should be its cost in proportion to its productiveness; but as has already been stated, the taste and appetite of the animal should be catered to, and heed should be given to the adapta-

bility of the ration to the special use to which it is to be put. A vast majority of the feeders of America find it necessary and profitable to use the product of the corn plant as the basis of all rations for all classes of stock.

It is clear that when feed is to be purchased, it should as far as practicable be selected with reference to supplementing, balancing or adding to the value of the material already on hand, rather than to purchase more of the same class. For example, it would not be good business policy to purchase timothy, kafir corn, sorghum, millet, or any of the straws, to feed with corn and stover, since such a combination adds nothing to the ration above the sum of digestible nutrients contained in the two feeds. Whereas if clover, alfalfa, cowpeas, bran, middlings, gluten meal, cottonseed meal or linseed meal be selected to combine with the corn products, the feeding value of the resulting ration would be directly increased. As practical illustrations of the value of combining such materials with corn products the following results of careful experiments are cited:

Dairy Cows—Jordan* reports the results of an experiment in which the yield of milk from cows when fed on six pounds of corn daily and all the timothy hay they would eat, was compared with the quantity of milk obtained from the same cows when fed on a balanced ration consisting of two pounds of corn meal, two pounds of cottonseed meal and two pounds of gluten meal, together with all the timothy hay they would eat. Both rations supplied practically the same quantity of digestible nutrients, but the proportion of protein was nearly twice as much in the mixed grain ration as in the corn meal ration. The results showed that during the time the cows were fed the balanced ration they

*Maine state college annual report, 1893, Page 81.

produced from one-fifth to nearly one-third more milk than when they were fed on the unbalanced ration, and that the yield of milk solids was from thirty to forty per cent greater.

Growing Steers—Waters* reports the results of several years' work with yearling steers, in which a gain from corn and timothy hay is compared with that from several other rations, in which the corn was at least partially balanced with cowpea hay, clover hay, etc. The following tables present a summary of the results:

COMPARISON OF BALANCED AND UNBALANCED RATIONS

First trial, 1899-00, 104 days, four steers in each lot, four pounds corn per day per head.

	Corn and timothy hay	Corn and cowpea hay
Corn eaten, lbs	1,568	1,568
Hay eaten, lbs	6,536	7,757
Total gain, lbs	260	624
Average daily gain, lbs	.64	1.54
Grain per lb gain, lbs	6.00	2.51

In this trial the substitution of cowpea hay for the timothy more than doubled the gain.

Second trial, 1900-01, 80 days, four steers in each lot, six pounds shelled corn per day per head.

	Corn and timothy hay	Corn and clover hay	Corn and millet	Corn and sorghum hay
Corn eaten, lbs	1,926	1,926	1,926	1,926
Hay eaten, lbs	1,543	5,719	3,941	4,727
Total gain, lbs	318	640	119	166
Average daily gain, lbs	1.00	2.00	.37	.52
Grain per lb gain, lbs	6.06	3.01	16.10	11.60

The results of the two experiments are in full accord. Note the difference in the amount of gain

*Missouri experiment station—Board of agriculture bulletins, September and October, 1901.

and in the number of pounds of corn required per pound of gain of the steers that were fed a balanced ration, in comparison with those which were fed an unbalanced ration of corn with either timothy hay,

BALANCED AND UNBALANCED RATIONS FOR FATTENING STEERS*

First trial, 1899-00, 119 days, four two-year-old steers in each lot, full fed on shelled corn.

	Corn and timothy hay	Corn and cowpea hay
Corn eaten, bushels	166	188
Roughness eaten, lbs	3,813	3,662
Total gain, lbs	802	1,257
Average daily gain per steer, lbs	1 69	2.64
Pounds grain per lb of gain	11 51	8.31
Gain per bushel of corn, lbs	4.87	6.74

Second trial, 1900-01, 105 days, four two-year-old steers in each lot, full fed on shelled corn.

	Corn and timothy hay	Corn and clover hay	Corn and cowpea hay
Corn eaten, bushels	157.5	176.2	175.3
Roughness eaten, lbs	2,530	4,768	4,783
Total gain, lbs	789	1,135	1,134
Average daily gain per steer, lbs	1.97	2.84	2.84
Pounds grain per lb of gain	11.19	8.69	8.65
Gain per bushel of corn, lbs	5.00	6.44	6.47

millet or sorghum. The corn when fed with either clover or cowpeas was more than twice as efficient as when combined with any of the other materials named.

Fattening Steers—Corn is conceded by all authorities to be the best single grain ration for fattening animals, especially when its low cost is considered. At

*Missouri experiment station—Board of agriculture bulletins, September and October, 1901.

Fig 53—What King Corn Can Accomplish

Part of the first prize car lot of Hereford steers at the 1902 Pittsburg fat stock show. Sold for $9.30 per 100 pounds. Fed and exhibited by T. McBaine, Columbia, Missouri

the same time the combination of corn with such foodstuffs as will increase the proportion of protein in a ration will result in a more rapid gain, as is clearly shown in the foregoing table of experiments recorded by Professor Waters of Missouri agricultural college.

EFFICIENCY OF MIXED RATIONS

These results are worthy of the most careful consideration. Taken in connection with those reported for yearlings, they indicate that the combination of clover or cowpeas with corn exerts a profound influence upon the efficiency of the ration as compared with corn and timothy hay. It will be noted that with the unbalanced ration of corn and timothy, each bushel of corn produced in one trial 4.87 pounds of gain, and five pounds in the other, or an average of 4.93 pounds for the two trials. When, however, the clover or cowpea hay was substituted for the timothy, each bushel of corn produced from 6.44 to 6.74 pounds of gain, or an average of 6.58 pounds, an increase of 1.65 pounds of beef from each bushel of corn fed. With steers selling at five cents a pound, this means that the feeder is getting eight and one-fourth cents a bushel more for his corn by balancing his ration with some such cheap material as clover or cowpeas. With corn at twenty-five or thirty cents a bushel, this is equivalent to an increase of twenty-five to thirty-three per cent in the returns from his feeding operations.

Not only is this true, but the steers will command a higher price on the market by reason of having gotten fatter, of finishing up smoother, and carrying more bloom. In the case of young cattle, the advantage is not all expressed in increased gain in weight, since the animal when wintered on a balanced ration is in condition to make better growth on grass or to

go into the feed lot and make rapid and economical gains.

Hogs—Plumb* reports the results of a feeding trial with pigs, in which corn meal was compared with equal parts corn meal and wheat middlings, with the following results:

CORN MEAL AND WHEAT MIDDLINGS FOR HOGS

	Average daily gain, lbs	Grain per 100 lbs gain, lbs
Corn meal	1.55	432
Corn meal and wheat middlings	1.68	406

Cottrell† reports the results of a number of experiments in which soy bean meal was used to balance the corn. A summary of these trials is presented.

BALANCED AND UNBALANCED RATIONS FOR HOGS

	No hogs in lot	Average gain per day	Grain per 100 lbs gain
First trial—			
Kafir corn meal—wet	5	1.85	471
Kafir corn meal four-fifths, soy bean meal one-fifth—wet	5	2.12	409
Second trial—			
Kafir corn meal—wet	3	1.21	559
Kafir corn meal four-fifths, soy bean meal one-fifth—wet	3	1.73	408
Third trial—			
Kafir corn meal—soaked 48 hours	5	.66	542
Kafir corn meal two-thirds, soy bean meal one-third — soaked 48 hours	5	1.15	374
Corn meal—soaked 48 hours	5	.74	484
Corn meal two-thirds, soy bean meal one-third—soaked 48 hours	5	1.08	369
Fourth trial—			
Kafir corn meal—dry	10	.83	749
Kafir corn meal four-fifths, soy bean meal one-fifth—dry	10	1.55	468
Fifth trial—50 days—			
Kafir corn meal—dry	10	.88	653
Kafir corn meal four-fifths, soy bean meal one-fifth—dry	10	1.73	435

*Indiana experiment station, bulletin 71.
†Kansas experiment station, bulletin 95.

From the above it is seen that in every case the soy bean meal had the effect of increasing the rate of gain and of cheapening the cost of production. Averaging all the work at the Kansas station, it was found that the six lots of hogs having soy bean meal as a part of the ration required 411 pounds of grain for 100 pounds of gain, while the nineteen lots not fed soy beans but given either kafir corn or corn, required 564 pounds of grain for 100 pounds of gain.

Corn as a Feed for Horses—So much has been said against the feeding of work horses on an exclusive grain ration of corn that much unreasonable prejudice has been aroused against its use for all classes of horses. This is especially true of the horse owners of the eastern states and of Europe. While it is not contended that corn alone should be fed for any great length of time to horses at work or young growing animals, at the same time it is fundamentally true that all things considered it is the most efficient and best single grain for idle horses and for those performing any class of work, and that it must form the basis of the ration for this class of stock as it does for all others, if due consideration is to be given to the economy of production. Perhaps the most elaborate experiments on record, in point of number of horses involved and the length of time over which the observations have extended, are those recently reported by M Lavalard of France. His investigations were begun for the Paris omnibus company, with the view of establishing a rational basis for the feeding of the large number of horses controlled by them under the different conditions of work, and have already extended over a period of twenty-five years, and later involved saddle horses and light draft horses traveling at a rapid gait; horses hauling light loads, and heavy draft horses hauling heavy loads at a slow pace. Altogether the obser-

vations have included some sixteen thousand horses belonging to the omnibus company, about seventeen thousand army horses, and one thousand horses used for heavy freighting. In summing up his conclusions on the use of corn, the following should have the effect of dispelling whatever prejudice may exist against the use of this feed for all classes of horses.*

"Our first experiments were made with Indian corn. They were undertaken with all kinds of horses and gave most satisfactory results. The Campagnie generale des voitures and the Campagnie generale des omnibus began about 1870 to feed Indian corn, and the results were so satisfactory that since that time the first named company has almost entirely ceased to feed oats. The latter company has continued to feed both oats and corn, effecting a saving of from one million to one and one-half million francs a year. In view of these facts, the opponents of corn have been forced to admit that it is a suitable feed for draft horses. They have insisted, however, that since it does not contain the so-called stimulating principle 'avenine' it should not be used for saddle horses and others where speed is required. Examples of the successful use of corn were cited in the author's earlier publications. The horses of the French expedition in Mexico were fed exclusively on corn. Our recent experiments on cavalry and artillery horses have shown that Indian corn may generally replace oats without in any way causing the horses to deteriorate. The horses fed the corn ration were used the same number of hours in the military drill and in the maneuvers, and were ridden at the same gait as those fed exclusively on oats, and it was practically impossible to perceive the least difference between the two classes. The army officers, prejudiced as *they naturally were, were forced to admit that all the horses* showed the same energy and vigor. A careful record showed that the sickness and mortality were the same with horses on the two rations.

"Corn and oats are quite similar in composition. In experiments made at the laboratory of the Campagnie generale des omnibus in co-operation with Muntz, the author found *very high coefficients of digestibility for corn*, as shown by the following results: Protein 86.1, fat 93.9, sugar and starch 100, crude fiber 82.8, saccharifiable fiber 86.9, undetermined substances 85.2 per cent. These coefficients show that the nutritive ingredients of corn are much more assimilable than has been generally believed in Europe. As regards physical character,

*Experiment station record, Volume XII, Page 14.

oats contain on an average 70 to 75 per cent of kernel and 25 to 30 per cent of indigestible hull, which resembles straw in composition. The skin or hull of maize amounts to practically nothing. These facts show why horses thrive better and are more apt to maintain their weight on corn than on oats. Our recent experiments have demonstrated that corn can replace oats in the ration of both cavalry and artillery horses, and if substituted weight for weight it increases the nutritive value of the ration. This is the same deduction which was drawn from experiments, now more than twenty-five years old, made for the two great cab companies of Paris."

Shepperd* compared a ration consisting of equal parts corn and oats with oats alone for mules at hard work, with the result that the animals on corn and oats made an average daily gain of seven-tenths of a pound, while those on oats alone lost six-tenths of a pound. He estimates that 77.5 pounds of corn is worth 100 pounds of oats for horses at work.

Corn as a Food for Poultry—For the fattening of all classes of fowls, corn is conceded to be unsurpassed, but the almost universal advice of poultrymen to eliminate this material entirely from the ration of laying fowls is perhaps based first upon the notion that the egg contains a large proportion of protein, and therefore only foodstuffs rich in this group of substances can be used to advantage, and second, doubtless to the unfavorable results obtained in practice from the exclusive use of corn for this purpose.

Some recent experiments by Brooks and Thompson† with several different breeds, in which complete laying records were kept for the two years covered by the experiment, clearly indicate that this prejudice against corn, when properly combined with other foodstuffs, is unfounded, and that by adding a reasonable amount of corn to the ration a large increase in egg production at a decreased cost will result.

In one trial wheat, oats, bran, middlings, animal

*North Dakota experiment station, bulletin 45.
†Massachusetts experiment station reports, 1899-00.

meal, corn and corn meal were fed to one lot of nineteen pullets, and to another lot of similar pullets the same ration was given, except that the middlings and gluten feed in the morning mash were replaced by corn meal, and the substitution of shelled corn was made for about half of the wheat and oats in the evening feed. The experiments were conducted in both winter and summer. The results show that the hens having the larger amount of corn instead of so much high-priced material, like wheat, middlings, oats, gluten feed, etc, produced from one-fourth to one-third more eggs at materially less expense for food; that the eggs from the corn-fed fowls were of milder flavor and had a yolk of deeper yellow color; that the fowls thus fed gained in weight despite the increased number of eggs produced; that on slaughter at the close of the experiment the fowls fed corn dressed more and were pronounced by an experienced market judge to be superior to those fed on the higher-priced ration.

In another experiment where the corn displaced the wheat and oats entirely as a night feed, but the ration in other respects was the same as in the previous trial, the results were even more strikingly favorable to the use of corn.

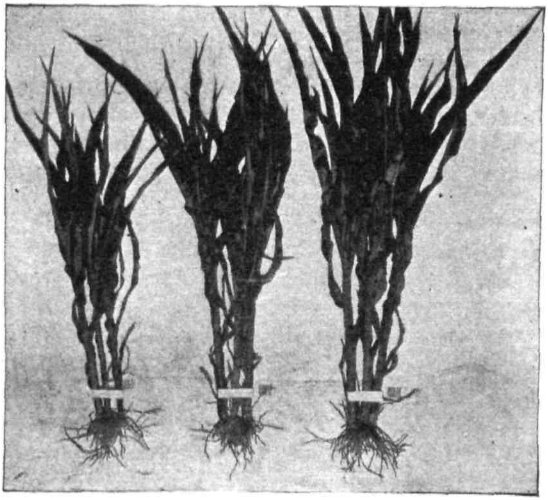
It is not to be concluded from these investigations that an exclusive ration of corn would prove satisfactory for this purpose, but that in the case of laying fowls, as with all other stock, corn, judiciously used, is the most economical and profitable foodstuff available. For the greatest profit in any feeding operation, it must form the basis of the ration.

THE MORE COMPLETE UTILIZATION OF CORN STOVER*

The second most important way in which the value of the corn crop may be increased to the farmer

*The corn plant after the ear is removed.

is in the more complete utilization of the corn stover. It is estimated that between eighty and ninety million tons of stover are produced on the eighty million acres or more planted to corn in the United States each year. The magnitude of this annual crop of roughness will be more fully appreciated when we consider that the annual hay crop of the United States is between sixty



1 2 3

Fig 54—Effects of Root Pruning

No 1, not pruned; 2, pruned four inches deep; 3, pruned six inches deep. See Chapter VIII

and seventy million tons, and is estimated to have a money value on the farm of something like five hundred millions of dollars.

Stover is carefully harvested and fed in the more densely populated states of the east. In the great corn belt of the middle west, where more than half the corn

of the nation is produced, there is a prodigious and profligate waste of this valuable material. In this section valuable land is used for the production of timothy hay upon every farm, to be used for roughness, and acres of corn stover are allowed to go almost entirely to waste.

Comparison of Nutrients in Ear and Stover—According to the investigations of Armsby* and others, the digestible nutrients of the entire corn plant are distributed between the ear and stover about as follows:

DISTRIBUTION OF DIGESTIBLE NUTRIENTS IN CORN

	Protein	Carbohydrates	Fat	Total	Per cent
In total crops, lbs......	327	3,774	147	4,248	100
In the ears, lbs.........	224	2,301	125	2,670	63
In the stover, lbs......	83	1,473	22	1,578	37

This table indicates that approximately 63 per cent, or practically two-thirds of the digestible material of the entire crop, is lodged in the ear, and about 37 per cent, or a little more than one-third, is found in the stover.

The corn grower perhaps does not realize when he harvests and utilizes only the ears that he willfully wastes more than one-third of the crop that he has been at the pains of growing.

CORN STOVER COMPARED WITH TIMOTHY HAY†

	Whole stover field cured %	Water free substance				Timothy hay for comparison %
		Whole stover %	Leaves %	Stalks %	Husks %	
Water..................	40.1	....	....	....	....	......
Ash	3.4	5.7	7.9	3.6	3.5	5.1
Fiber... ,..............	19.1	33.0	30.6	34.8	32.2	33.5
Fat.....................	1.1	1.7	1.9	1.6	1.4	2.9
Protein...........	3.8	6.4	8.6	5.9	5.0	6.8
Nitrogen free extract.	31.9	53.2	51.0	54.1	57.9	51.7

*Pennsylvania state college report, 1887.
†Lindsey United States Year Book, 1896.

DIGESTIBLE NUTRIENTS IN ONE TON OF STOVER AND ONE TON OF TIMOTHY*

	Corn stover, lbs	Timothy hay, lbs
Fiber	353.7	296.1
Fat	13.5	33.1
Protein	53.1	55.4
Nitrogen free extract	544.6	553.6
Total	964.6	938.2

It is safe to discount these figures for the coarse, rank-growing stover of the corn belt, for experience teaches that this material is not so palatable and probably not so digestible as the smaller and finer stover produced in the north and east.

Coarse Stover Valuable—At the same time, the results of all experiments and of experience abundantly prove that even this coarse stover has a feeding value that will fully justify the labor, pains and expense of harvesting and feeding it. The waste of this food that occurs in many sections from merely topping the stalk, leaving the blades below the ear and the husks to waste, is not from any point of view justifiable or economical, much less the more common practice in the corn belt of allowing most of the corn to stand in the field until harvested, and allowing all of the stover to waste except the little that the stock may eat in gleaning the stalk fields late in the season.

The Feeding Value of Corn Stover—The results of experiments by the Missouri experiment station extending over six years, with yearling and two-year-old steers, both with and without grain, will enable us to form a fair estimate of the feeding value of this material as compared with timothy hay, which is accepted as the commercial standard, at least, of all rough fodders. In all of these trials, large coarse

*Stover computed on basis of twenty per cent moisture.

stover from corn yielding sixty to seventy bushels of grain an acre was used. It was allowed to stand in the open field in what is commonly known as sixteen-hill-square shocks until required for feeding, and was fed whole. The timothy was harvested when the seed was in the dough state, and the hay was either preserved in the mow or in large ricks. Undoubtedly the smaller stover of the north or the finer material grown especially for fodder would show a higher palatability and feeding value, but it is this coarse stover which is mainly wasted, and the results of these experiments are therefore directly applicable to the ordinary conditions of the middle west.

TESTS WITH STOVER AND TIMOTHY

Comparison of the feeding value of stover and timothy—Yearling steers—No grain—Results computed on the basis of 1000 pounds live weight—Three years' work.

	Food eaten daily per steer, lbs	Per cent refused	Dry matter eaten daily	Total gain or loss in weight, lbs
First trial—				
Timothy hay	16.5	23.0	14.1	29.0
Whole corn stover	25.5	35.0	19.5	—2.0*a*
Second trial—				
Timothy hay	22.3	18.6	18.7	21.7
Whole corn stover	22.9	44.7	17.5	—11.8*a*
Third trial—				
Timothy hay	21.7	12.0	17.8	30.8
Whole corn stover	28.9	42.0	22.6	13.8
Average—				
Timothy hay	20.2	17.9	16.9	30.7
Whole corn stover	25.8	40.6	19.9	00.0

a — denotes loss in weight.

From these results it appears that when corn stover alone was fed, the animals neither gained nor lost in weight, averaging the three years' work, while those having all the timothy hay they would eat made a slight gain. More dry matter was uniformly con-

sumed daily by the steers on stover, and a considerably larger proportion of the material fed was refused than in the case of the timothy. Taking all these facts into consideration, it is safe to estimate that, ton for ton, stover has approximately half the feeding value of timothy hay when each is used as an exclusive ration. That it is not good business policy, however, to winter cattle in this way in the ordinary season will be accepted without argument.

Increasing the Value of Stover—That it is easy to so increase the value of stover by combining it with some such material as clover, cowpea hay or alfalfa, that it will even exceed timothy when the timothy is fed alone or in combination with corn, will be perfectly clear from the results of further trials at the Missouri experiment station:

FEEDING STOVER WITH CLOVER HAY

Combination of stover and clover compared with timothy—Yearling steers—No grain—Results computed on the basis of 1000 pounds live weight.

	Timothy hay	Equal parts whole corn stover and clover hay
Food eaten daily per head	21.7	25.2
Per cent refused	12.0	28.0
Dry matter eaten daily, lbs	17.8	21.6
Gain in weight per steer	30.8	58.4

In this case a ton of stover and a ton of clover hay when fed together fully equaled two tons of timothy.

Other trials in which a small amount of shelled corn was added to the ration fully confirm these results, as shown on Pages 215 and 216.

A Substitute for Timothy—Thus it appears in every case, whether fed without grain, with a small allowance of grain, or on full feed; whether with yearlings or aged cattle, a combination of corn stover and

clover hay proved superior to timothy hay. In other words, the farmer is able by this means to make the stover serve every purpose, in cattle feeding, at least, for which timothy is now used. Under these circumstances it is fair to say that timothy and stover have at least equal feeding values. It is quite probable that where such hays as clover, alfalfa and cowpeas are

FURTHER EXPERIMENTS WITH STOVER AND HAY

1899, yearling steers, 104 days, four steers in each lot, four pounds corn per head per day.

	Corn and timothy hay	Corn, clover hay and corn stover
Corn eaten, lbs	1,568	1,568
Roughness eaten, lbs	6,536	*a*3,593 *b*3,631
Total gain, lbs	260	356
Average gain per day per head	.64	.88
Grain per pound gain	6.00	4.40

a Clover hay. *b* Corn stover.

1900, yearling steers, 80 days, four steers in each lot, six pounds corn per head per day.

	Corn and timothy hay	Corn, clover hay and corn stover
Corn eaten, lbs	1,926	1,926
Roughness eaten, lbs	4,543	*a*3,619 *b*2,298
Total gain, lbs	318	443
Average daily gain, lbs	1.00	1.35
Grain per pound gain	6.00	4.45

a Clover hay. *b* Corn stover.

not available, a small quantity of cottonseed meal, linseed meal, gluten meal or bran may serve the same purpose and accomplish the same result, viz, of enabling the feeder to use his stover to the best possible advantage, and as a complete substitute for timothy. It is needless to say that the accomplishment of this

result would be attended by an immense increase in the net returns from the corn crop. The annual stover crop would then represent a valuation to the farmers of something more than a quarter of a billion dollars. No farmer would willfully permit the waste of his tim-

FATTENING STEERS

Comparison of timothy with equal parts stover and clover hay for steers on full feed.

1899, two-year-old steers, 119 days, four steers in each lot, full feed of shelled corn.

	Corn and timothy hay	Corn, clover hay and corn stover
Corn eaten, bushels	166	185
Roughness eaten, lbs	3,813	*a*1,626 *b*1,889
Total gain, lbs	802	917
Average daily gain, lbs	1.69	1.94
Grain per lb gain, lbs	11.51	11.29
Gain per bushel of corn	4.87	4.96

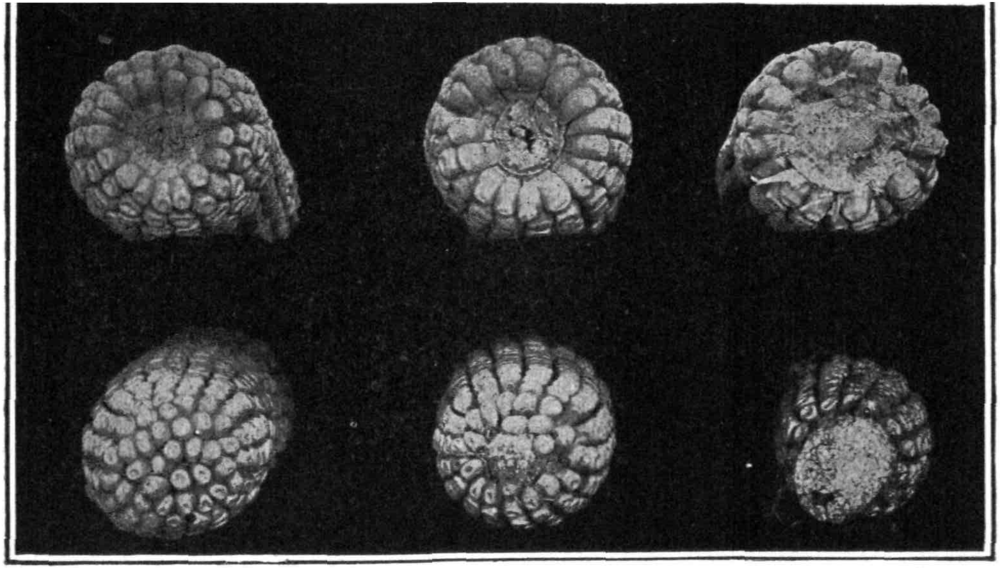
a Clover hay. *b* Corn stover.

1900, two-year-old steers, 105 days, four steers in each lot, full feed of corn.

	Corn and timothy hay	Corn, clover hay and corn stover
Corn eaten, bushels	157	176
Roughness eaten, lbs	2,540	*a*2,475 *b* 868
Total gain, lbs	789	1,140
Average daily gain, lbs	1.97	2.85
Grain per lb gain, lbs	11.19	8.30
Gain per bushel of corn	5.00	6.74

a Clover hay. *b* Corn stover.

othy crop after it had been grown and required only to be harvested to be available as a feed. There is in the light of the results of the foregoing experiments quite as little justification for the waste of his stover.



313 314 315

Fig 55—Butts and Tips of Boone County White

No 310, deeply rounded, proper shape; 311, medium butt; 312, very shallow rounded, poor butt; 313, proper shaped, well-filled tip; 314, a medium tip; 315, a very poor tip. See Chapter II

SILOING VS FIELD CURING

The practice of preserving the green corn plant in the silo has grown rapidly in favor, especially with the dairy farmer. It commends itself upon the ground that a large quantity of material may be stored in a comparatively small space. Green and succulent food is thereby provided for the winter months. The green plant is more palatable, the coarser parts of the stalk being much more completely consumed when made into silage. The harvesting is done during the pleasant weather in the early fall, and the drudgery of handling dry stover in winter is obviated. It is cheaper on the whole than to be at the expense of husking and grinding the ears and cutting or shredding the stover. It does not appear to affect the digestibility of the material favorably or unfavorably.

Silage and Field-Cured Corn Fodder—Experiments have been made at the Vermont and Wisconsin stations, in which two rows of corn across the field were cut and placed in shocks, while the next two were run through the feed cutter and placed in the silo. By thus alternating until the silo was filled, equal quantities of material cut at the same time and from the same field were obtained. The field-cured fodder was later run through the feed cutter and fed in comparison with the silage to dairy cows, with equal quantities of hay and grain.*

The results at the Vermont station were as follows: The 14,262 pounds green fodder corn when dried, fed with a uniform daily allowance of hay and grain, produced 7688 pounds of milk. The 14,262 pounds of green fodder corn converted into silage, and fed with the same daily ration of hay and grain, produced 8525 pounds of milk.

At the Wisconsin station the results were: From

*Henry's Feeds and Feeding.

29,800 pounds of green fodder were obtained 24,440 pounds of silage, which, fed with 1648 pounds of hay and 2884 pounds of grain, produced 7496 pounds of milk, containing 340.4 pounds of fat. From 29,800 pounds of green fodder were obtained 7330 pounds of field-cured fodder corn, which, fed with 1567 pounds of hay and 2743 pounds of grain, produced 7119 pounds of milk, containing 318.2 pounds of fat.

At the Vermont station the silage ration produced 837 pounds, or 11 per cent, more milk than was obtained from the dry fodder ration. At the Wisconsin station the silage ration yielded 377 pounds more milk and 22 pounds more fat, a difference in favor of silage of 5 per cent in milk and 6 per cent in fat.

Losses in the Siloing and Field Curing—Whether the changes which occur in the silo be due to the activity of certain ferments, as has been held for a long time, or whether the results of recent investigations, indicating that these changes are mainly due to respiratory processes which continue as long as the plant cells live, be accepted, the more important fact to the feeder remains unaltered, that these changes are accompanied by a material loss of organic matter, and that such loss is largely proportionate to the amount of oxygen or air admitted to the mass. That the more perfectly the mass be compacted, and the more nearly air-tight the silo, the less the loss. The necessary, or at least unavoidable, loss under practical conditions seems to be approximately fifteen per cent of dry matter—that is, the feeder takes out of the silo between one-seventh and one-sixth less dry matter than he puts in. It is moreover true that the loss falls most heavily on the sugars, which are more or less completely converted into acids. To some extent changes occur in the nitrogenous compound which affect adversely their feeding value.

Attention has been sharply drawn to these losses in preserving silage, with the result that many have been deterred from adopting this system. Careful inquiries in a number of states into the losses accompanying the field curing process amply justify the conclusion that under the most favorable conditions they are quite as large as in the siloing system, and under ordinary circumstances are considerably larger. The loss in feeding the dry fodder, the uneaten portion of the stalk, must be added to the unavoidable loss in field curing. In the experiments already quoted with coarse stover, this loss amounted to approximately forty per cent of the total weight of fresh substance fed, while in the same experiment less than eight per cent of the silage was refused. While this portion of the plant is not perhaps as digestible, and certainly not as palatable as the portion eaten, yet experiments by Jordan and Patterson show that a considerable amount of digestible matter is contained in the lower half of the stalk which is available to the animals if they can be induced by any practical means to consume it. In overcoming this loss, or in inducing the animals to eat practically all of the plant, lies perhaps the greatest single benefit to be derived from siloing.

Finally, the advantage of silage over field-cured material to the dairyman has been proved by an abundance of practical experience. Experiments made at the Missouri station clearly indicate that for wintering stock cattle of all classes it possesses decided advantages over the field-curing system. For cattle on full feed the testimony is conflicting, and there is yet some doubt as to whether it is feasible under ordinary circumstances to feed steers that are carrying considerable flesh very much silage. For sheep its value is already well recognized.

Silage vs Roots—Many feeders concede the ne-

cessity for some succulent food during the winter months, who, however, insist that some one of the root crops is more satisfactory than silage, basing their opinion upon the belief that a larger yield of dry digestible matter may be produced with roots than with corn, and that the roots have a materially higher feeding value. It will not be contended that an acre of roots can be grown, harvested and fed as cheaply as an equal area of corn. On the contrary, the results of careful experiments and the most reliable estimates from experienced and successful growers indicate that an acre of roots will cost under the most favorable circumstances fully three times as much as an acre of corn.

From an experiment extending over three years at the Pennsylvania station by Professor Waters, it was found that the yield of digestible matter in mangels or sugar beets was on the average about half that of corn. In other words, it required approximately two acres of beets to be equivalent in this respect to one acre of corn. Attention is invited to the following table showing the comparative yields of corn and roots at a number of the stations:

DRY MATTER PER ACRE, ROOTS AND GREEN FODDER CORN

	Rutabagas	Mangels	Turnips	Sugar beets	Corn
Maine station—					
Green substance, lbs	31,695	15,375	28,500	17,645	39,645
Dry matter, lbs.....	3,415	1,613	2,559	2,590	5,580
Pennsylvania stat'n—					
Green substance, lbs	......	16,177	......	11,436	18,591
Dry matter, lbs......	......	2,382	......	2,010	5,522
Ohio station—					
Green substance, lbs	......	31,500	......	......	......
Dry matter, lbs......	......	3,000	......	......	6,000
Ontario station *a*—					
Green substance, lbs	42,780	55,320	46,120	32,663	41,172
Dry matter, lbs......	4,877	5,034	4,382	4,737	8,135

a Henry's Feeds and Feeding.

In view of the fact, therefore, that beets are fully threefold more expensive to grow and yield only about half as much digestible matter, it would be necessary for them to possess approximately six times the feeding value of corn silage in order to establish even a parity between the two classes of foods.

Careful experiments, however, in Pennsylvania, Ohio and Vermont show beyond question that there is little or no difference between the feeding value of the dry matter of the two feeds, and the small difference was found to be uniformly in favor of the silage. From every point of view, therefore, the great disadvantage of root crops in competition with corn is perfectly apparent.

Soiling—No plant now known to us equals corn in its adaptability to the soiling system. Varieties may be selected which will yield a continuous crop of succulent food, mature enough to have a high feeding value, from the middle of June until the severe frosts of autumn. The practice of relying upon corn almost exclusively from the time the earliest variety can be brought to a reasonable state of maturity until the close of the season, is well founded and fully justified by the results of scientific research. Corn has the advantage of yielding a larger quantity of digestible matter per acre at less cost than any other crop suited to soiling, and furthermore it may be harvested, handled and fed more conveniently than any of the other crops used, and has a higher feeding value.

The problem with those who follow this system is to find some plant to cover the period of early spring before corn can be brought to maturity. In the solution of this problem it has been found that corn silage kept over from the preceding season will answer this purpose more fully and more satisfactorily than any crop that can be grown at that season of the year.

Thus the corn plant lends itself to the farmer who by reason of limited area and high-priced land is forced to produce the largest possible quantity per acre, quite as well as to the farmer on the broad, fertile prairies of the west, where the greatest possible number of acres must be managed by one man.

CHAPTER XIII

Marketing

THE wisest distribution of an annual crop of corn, exceeding two billion bushels, is no less important to farmers as a whole and to the maize grower in particular than is its economic production. Fortunately for all, our splendid corn crop never "goes a begging." There is always an outlet for every bushel. The amount carried over from one crop year to another is never burdensome, except in the mind of the bearish operator, whose wish is father to the thought when he says the surplus is too large.

As shown on other pages, the states growing more corn than needed for home use are located principally in the Ohio valley and the Mississippi basin. Iowa, Illinois, Kansas, Nebraska, Missouri, Indiana and Ohio are popularly known as the seven great surplus corn states, because they grow enough for their enormous home consumption and also have liberal quantities to ship outside their borders. In recent years Texas has also greatly increased the corn area, but the product goes principally toward maintaining her extensive live stock interests.

The splendid home demand in these states, as well as in every state where corn is grown, is one of the most satisfactory features in crop distribution. Corn grown at home and converted into beef, pork, mutton and dairy products is a commonplace, yet none the less a valuable example of the merit of changing over raw material into finished product, adding directly to the gain of the farmer and to the wealth of the country.

THE HOME MARKET THE BEST MARKET

Roundly speaking, ninety per cent of the corn crop of the United States is wanted for domestic consumption. In the states given over so extensively to corn, at lowest cost of production, it is but natural that feeding operations on the farm are most largely carried on, and the bulk of the crop never leaves the counties where grown. This, therefore, disposes of most of the product each year to what may be truly characterized a home market of the best sort. The comparatively small, yet important proportion of the maize crop not fed at home, finds ready outlet through the usual market channels. A considerable amount is used in the domestic mechanic arts, and foreign countries are always interested buyers of any surplus beyond home requirements.

In the grain trade, corn is the leading cereal in bulk and second only to wheat in speculative interest. Corn forms an important item in rail, lake and canal transportation, and also in the cargo of vessels engaged in the ocean-carrying trade. The approved methods of handling corn, producer to consumer, are not necessarily perfect, but are the best yet evolved in the economy of distribution. Fortunately for the corn grower who desires to market this product in the form of grain, middlemen's tolls are reduced to a minimum compared with those exacted in the handling of perishable, and therefore more hazardous products.

METHODS OF DISTRIBUTION IN VOGUE

To many farmers in the corn belt, long engaged in growing this crop for market, methods of marketing are an old story. To others, including the vast number of farmers and dairymen in the older middle and eastern states, who depend to some extent upon west-

ern feedstuffs, a brief outline of methods in vogue will be read with interest and profit.

The first step in the flow of corn from farm to ultimate consumption is to the great distributing centers of the west, known as primary points. These include Chicago, Kansas City, St Louis and others of less importance. The second stage begins at these distributing centers in the grading, temporary warehousing, storing and reshipment via rail, river and lake. The destination is eastern or southern distributing centers of secondary consideration, and tide water resting places for loading into ocean vessels for foreign countries.

Transportation—Rates of freight from country loading station to primary market or to the seaboard, rates of commission for handling, storage charges, etc, together with the current price of the various grades every business day in the year, are easily available to the farmer and the country dealer. All such may be relatively as well posted on market conditions as the big operator on the Chicago board of trade or on the New York and foreign produce exchanges. Theoretically, the farmer with a single carload of corn enjoys as good an opportunity to secure full market value for his product as the operator on a large scale, but this does not always follow. In spite of legislative effort to equalize freight rates, and the work of the Interstate Commerce Commission, transportation companies too frequently make it possible for the large shipper to enjoy rebates, giving him enormous advantage over others, including the farmer with a single carload.

THE LINE ELEVATOR SYSTEMS,

covering a large part of the corn belt, now handle an important part of the corn as originally sold by pro-

ducers. Some one of these may own or control a score, or fifty, or a hundred country elevators at as many shipping stations, each operated by an agent of the company, which in turn works in harmony with the railroad system covering the same territory. The prices paid farmers for corn are very largely governed by current quotations in the big distributing centers, freight rates duly considered. In many instances, farmers feel they do not secure all the market will stand, through lack of competitive bidding, and gladly welcome the advent of outside buyers. This is what has brought so rapidly to the front in the past few years the "farmers' elevators," described on another page.

The country buyer, no matter whether representing a line elevator or an independent concern, must be a good judge of grade and quality in the city markets. After temporary storage, and possibly cleaning at country point, the corn is shipped to a great distributing center, such as Chicago, where the car is inspected by the state grain inspection department and graded according to the classifications of that presumably impartial body.

PUBLIC GRAIN WAREHOUSES

In order to handle the grain crops quickly and economically, enormous storage facilities are necessary, both at centers of accumulation in the grain growing states, at various transfer points on the Great Lakes and at tide water. Mention has been made elsewhere of the country elevator systems, also allusion to warehouses at the seaboard. In accompanying cut (Fig 58), a typical modern grain warehouse is shown. An idea of its bulk and magnitude is afforded by comparing its hight with that of the trains of cars which are pushed directly into and through it for loading and unloading. This elevator, located in Chicago, has a

capacity of one million bushels grain, and, like dozens of its fellows, is equipped with all modern arrangements in the way of tracks, elevators, bins, etc.

Under the rules of the Chicago board of trade, and this is substantially true of other leading grain exchanges, licenses are each year granted various warehouse systems, declaring them "regular" houses for the storage of grain and flaxseed. These are under the supervision of the state grain inspection department, and all grain and seeds handled therein are represented by negotiable warehouse certificates, which enter largely into the grain traffic. The total capacity of the regular warehouses in Chicago is twenty-seven million two hundred and fifty thousand bushels. In addition to these are a considerable number of what are technically known as "irregular" warehouses, the proprietors for various reasons not caring to operate them under the rules of the board of trade. These outside houses have a total capacity of thirty million four hundred and seventy thousand bushels, and there is here suggested an aggregate capacity for the storage of fifty-seven million seven hundred and twenty thousand bushels grain in Chicago.

Under the rules of the Chicago board of trade the established storage rate of grain and flaxseed received in bulk is three-fourths of a cent per bushel for the first ten days, and one-fiftieth of a cent per bushel per day for each additional day thereafter.

Inspection rules relating to corn vary somewhat in different states. As a fair index of trade requirements, herewith are printed the rules governing inspection of grain in Chicago, according to the specifications of the state board railroad and warehouse commissioners.

No 1 yellow corn shall be yellow, sound, dry, plump and well cleaned.

No 2 yellow corn shall be three-fourths yellow, dry, reasonably clean, but not plump enough for No 1.

No 3 yellow corn shall be three-fourths yellow, reasonably dry and reasonably clean, but not sufficiently sound for No 2.

No 2 white corn shall be seven-eighths white, dry, reasonably clean, but not plump enough for No 1.

No 3 white corn shall be seven-eighths white, reasonably dry and reasonably clean, but not sufficiently sound for No 2.

No 2 corn shall be mixed corn, dry, reasonably clean, but not good enough for No 1.

No 3 corn shall be mixed corn, reasonably dry and reasonably clean, but not sufficiently sound for No 2.

THE SALE OF CORN BY SAMPLE ON 'CHANGE

Unless previous distribution has been arranged for, the car is generally consigned to a commission merchant, who takes a portion of the official sample furnished by the inspection department, with the then known grade, the sample representing a fair average of the contents of the car. The inspection department temporarily reserves its own portion of the sample in case of controversy. Very often the commission merchant also takes an independent average sample of the car for purposes of comparison. These samples, with grade and car number attached (with hundreds of their fellows) are offered on 'change, and are sold on their merits the same as any other commodity in mercantile life, whether it be cotton goods, raw wool, pine shingles, or iron ore.

The buyers represent many interests; those engaged in the shipping business want to make up a cargo of corn for Buffalo or New Orleans, or for export account; a distiller or a glucose house wants a

round lot for manufacturing purposes; a miller wants a car for grinding. Oftentimes the buying is for account of city elevator concerns, which accumulate large quantities, using same for speculative purposes, and ultimately for shipment to the seaboard and foreign countries.

The price, however, in any instance is governed very largely by the speculative market. This in turn is dominated by influences emanating not only from the Chicago corn pit, but from the seaboard markets, and from conditions in western Europe which, after all, very largely determine what shall be paid for the surplus grain crops of the entire world. Trading is on a spot cash basis, and the transaction may be made much quicker than the time required to describe it. After deducting freights, commission charges, etc, a check in payment is immediately sent the country shipper, and the transaction is complete so far as he is concerned.

Rates of commission for selling corn on the produce exchanges are fairly uniform; on the Chicago board of trade one-half cent per bushel is the established rate. Other charges include storage, if any, inspection, etc.

THE SPECULATIVE TRADE IN GRAIN

The produce exchanges, or the boards of trade, terms generally used synonymously, serve as clearing houses for transactions in farm produce as here indicated. The line of demarcation between the so-called "purely speculative" and "strictly legitimate" transactions is so fine at times that it is scarcely discernible. Suffice it here to say that influences affecting grain prices are often and largely speculative in a world-wide sense.

Influences Affecting Prices—To be thoroughly successful, the farmer who grows corn for market

must keep posted on general conditions. It is not sufficient to know that there is a crop shortage in his own state, or, on the other hand, one more than abundant. The probabilities of the domestic consumptive demand should be familiar; to the one handling grain, something of reserves carried over from a preceding crop; conditions abroad, as to probable requirements for feed purposes; crop outlook, etc. The export demand and the foreign markets, while not so important in corn as in wheat, are always influential in shaping home prices, except in seasons of crop shortage (such as 1901-2), when this is less pronounced.

Selling "Short" in Speculative Market—The speculative end of the corn market is made up very largely of "short sales," by bearish operators. These believe they can sell the contract grade at the then existing market price, even though they do not possess it, with a view of subsequently, say within sixty or ninety days, buying it in lower, on these time contracts, and keep the difference as profit. Short selling has been decried for many years, and the subject of frequent hot contests, not only in trade channels, but in state and national legislatures. Much may be said on both sides of this great question.

While in nowise standing sponsor for the speculators, it is proper here to state the attitude of so responsible an organization as the Chicago board of trade. This can best be epitomized in a brief paragraph from the report of a special committee, several years ago appointed by the board of directors of the Chicago board of trade to investigate a proposition to change the method of doing business to a system popularly termed spot cash, eliminating entirely buying and selling "futures."

"By the form of contract under which members of the board of trade buy and sell property for future delivery, either

party can compel its literal fulfillment by the original parties thereto, and neither party can (without the consent of the other) escape his obligation under and upon such contract, to deliver or receive the actual property described in its provisions. The fact that a large proportion of the contracts entered into are closed at the market price, instead of by actual delivery of property, argues no more against them than that the present bank clearing-house system does not require the passing of the currency by each bank upon each individual check that is drawn in due course of general business."

Nearly all the corn received at Chicago in a given year is handled on the board of trade. The receipts of corn during the calendar year 1901 were 84,136,637 bushels, and in 1900, the heaviest on record, 134,663,456 bushels. In 1902 the movement was smaller, amounting to 50,622,907 bushels. During the past forty years, which practically covers the period of speculative trading in corn, Chicago received in round numbers 2,500,000,000 bushels. Other leading primary markets include Kansas City and St Louis, with a considerable quantity also received from first hands each season at Cincinnati, Toledo, Detroit, Milwaukee, Omaha and Minneapolis.

Fig 56 affords a good idea of the substantial character of the English grain warehouses. This warehouse is close to the Alexandra docks at Liverpool and is one of the largest in the United Kingdom. It has five delivery subways, each of which can handle eighty tons of grain an hour. It contains two hundred and fifty bins, hexagonal in shape, each seventy-five feet deep, thirty-five feet wide, with a capacity of two hundred and twenty tons, a total for the warehouse of two million bushels. Grain is transported in ocean vessels, both in bags and in bulk. The warehouse fronts the Mersey, the unloading being done direct from vessel with machinery of the most perfect character.

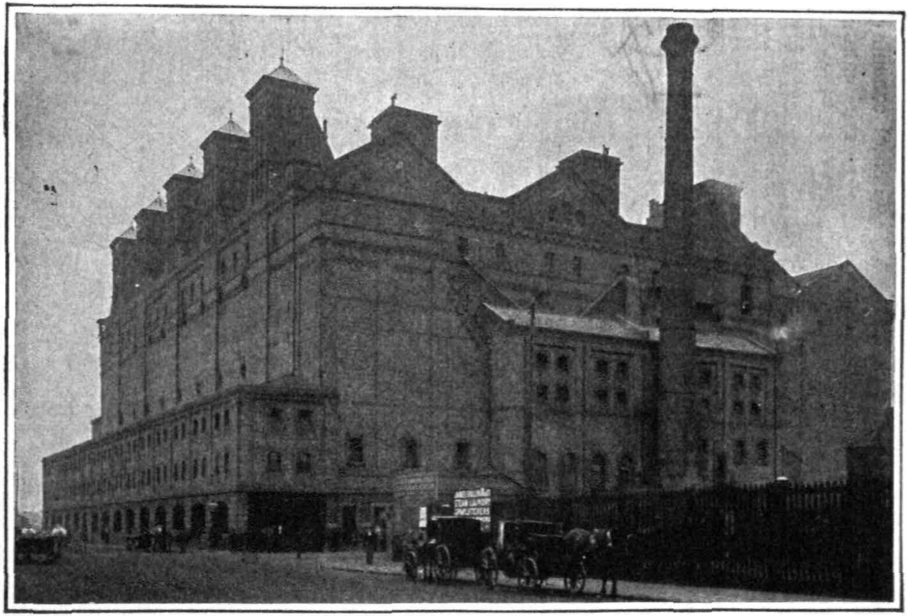


Fig 56—Grain Warehouse at Liverpool
Brick construction

THE NON-FARM CONSUMPTION OF CORN

In the United States this is important, affording considerable aid to market prices. The chief consumers under this head are the distilleries, starch manufacturers and glucose works. A business of much magnitude is done in milling corn for table purposes, with such resultant products as corn meal, corn flour, blended flour (a mixture of wheat flour and corn flour) and breakfast cereals. Enormous quantities of coarse corn meal and mixed feeds, including such by-products as gluten meal, are used in the cities and in dairy sections west and east. No figures are available showing the proportion of the crop utilized under this head. Further details regarding these products may be found in the chapter on New Uses of Corn.

Glucose, the sugar of corn, results from the transformation of the starch in the corn by chemical process. Another by-product of corn is dextrin, largely used in the manufacture of mucilages and sizes. Corn oil is one of the most important by-products in the manufacture of glucose, is used to some extent in making soap, but largely for mixing with other oils, owing to its emulsifying properties. Starch is a very important by-product of corn, turned out not only by starch factories but also by glucose manufacturers, meeting extensive sale for laundry purposes, as a size, and for use in cotton mills.

Increasing Importance of Corn Oil—Corn oil possesses a fine flavor, and is often mixed with olive oil and sometimes is used in Norway for mixing with cod liver oil. Naturally, when bottled and labeled, there is no reference to the fact that any portion of the mixture in either case is corn oil. The wholesale price of the last-named is about thirty to forty cents per gallon. Corn oil is used to some extent as a substitute for lin-

seed oil in painting, owing to its lower price. It dries more slowly than linseed oil. Manufacturers are endeavoring to increase the supply of corn oil, for use in the mechanic arts, by the aid of a naphtha and steam process long followed in France in extracting vegetable oils. Some progress has been made in the use of corn oil in producing a substitute for rubber by a process of vulcanization. Vulcanized corn oil may be mixed with pure rubber in various proportions, the resultant being softer and less elastic than pure rubber, but also equally acid proof. It enters into the manufacture of rubber boots, bicycle tires, etc, greatly reducing the cost of the finished product. It is not as good as rubber.

Considerable quantities of corn oil are now exported, chiefly to Belgium, Holland, and the United Kingdom, in about the order named. In the fiscal year 1902 exports of corn oil from the United States were 4,266,398 gallons, at an average value of forty-one and one-half cents; of this 2,933,650 gallons went to Belgium. In 1901 exports were 4,808,545 gallons, having an average value of thirty-eight cents; of this amount 3,005,000 gallons went to Belgium. Total exports in 1900 were 4,383,926 gallons, in 1899 2,360,623 gallons and in 1898 2,646,560 gallons.

FOREIGN OUTLET FOR AMERICAN CORN

Our foreign trade in corn has assumed important proportions and is in a most healthy condition. Never firmer established than now, exports following a good crop easily approximate 200,000,000 bushels in a year. When prices are unusually high in seasons following a domestic crop shortage, as was the case in 1902, 1894 and 1891, exports are materially reduced.

Up to the present, the foreign use of corn is con-

fined very largely to rations for meat animals and work horses. In recent years valuable aid has been given our foreign trade through the education of Europe to a wider use of corn. The work of the American Maize Propaganda in the late nineties and at the Paris exposition in 1900 was along this line. Possibilities are great, especially on the continent, where rye is now so largely used as an article of food. Efforts are being made from time to time to induce some of the governments to utilize corn meal as an army ration.

The largest buyers of American corn are England, Germany, Holland and Denmark, in about the order named. Canada is a heavy buyer. The West Indies are taking increasing quantities, and this splendid cereal finds an outlet in various other parts of the world, including South America, Africa, Mexico and, in a small way, Asia and the Pacific Islands. Argentine corn is something of a competitor in the old world markets, which include Europe, South Africa, etc. Argentine exports of corn are ten to sixty million bushels annually. See Appendix, later pages, for detailed official figures showing foreign movement of corn. The United States produces more than eighty per cent of the world's corn crop. The next largest producers are Austria-Hungary and Argentina.

Floating elevators are largely used in transferring grain from vessels to warehouses, both on this side of the Atlantic and in Europe. That illustrated in Fig 57, with various modifications, is largely used in Liverpool in unloading grain from vessels. It contains a lifting apparatus operated on the usual principles, and does the work rapidly. A large part of the American grain destined for foreign markets is sold "c i f" (cost, insurance and freight), the marine insurance and ocean freight being included in the cost.

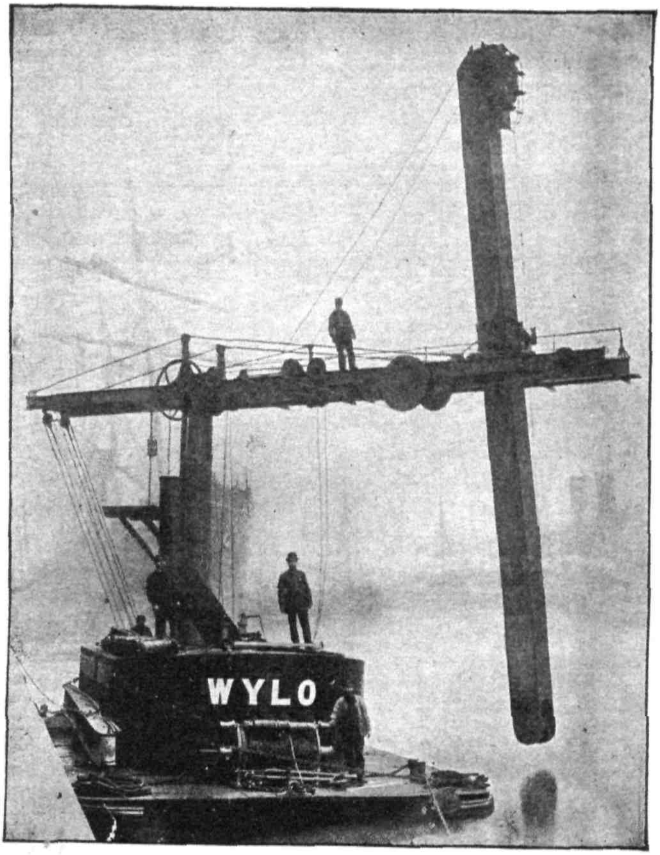


Fig 57—Floating Grain Elevator
Used to some extent at English seaports

MERITS OF THE COUNTRY ELEVATOR SYSTEM

Farmers' elevators and co-operative societies for the economical handling of corn in producing sections are increasing in number. This is particularly true in territory west of the Mississippi river. Where independent or "line" elevators lack in competitive bidding, or refuse to pay prices satisfactory to producers, city markets considered, the farmers' elevators find a true place. These are usually organized on the co-operative plan, farmers adjacent to a given shipping point choosing their own officers and manager, subscribing for the stock, erecting a new warehouse and elevator, or buying and refitting an old one.

Attitude of Railway Companies—As a rule these are quite willing to grant switching facilities, in their logical effort to develop the production of any given commodity which will mean more business. The charter being secured, and the elevator built and equipped, the farmers' company buys grain from producer and operator as any other business concern. The grain dealers' associations operating in various western states, and largely made up of line elevators, or those with important terminal connections, generally oppose the farmers' elevators. In some of these co-operative institutions each shareholder is limited to one vote, no matter how many shares he may hold.

At times, when other dealers promise to pay more for grain than this elevator, farmers will be allowed to sell to the opposition elevator. Proper restrictions are observed, however, to prevent grain combinations from breaking up the farmers' organizations through temporarily paying a stiff advance, perhaps more than market conditions warrant. Growers patronizing farmers' elevators claim they get the benefit of the premium arising from the superior grade of their local product;

that they secure the full value of the grain, freights and other charges considered, at a time when the bulk of it leaves the farm. Another advantage is the possibility of storing grain for a time in this farmers' elevator at a minimum charge, with a view of selling later at a possibly higher market price.

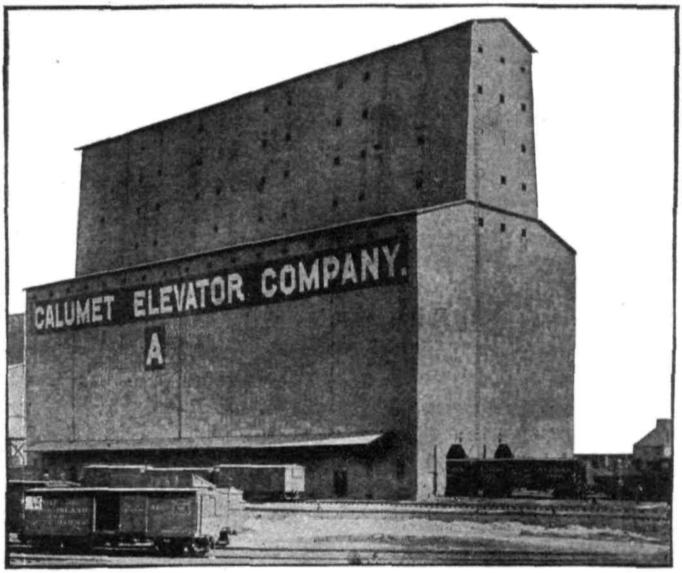


Fig 58—Typical Modern Grain Warehouse

CO-OPERATIVE STORING AND SELLING

Co-operative societies have in numerous instances made a great success in handling corn and other cereals. Often these societies are formed with a view of also buying and handling farm machinery, building material, fertilizers, seeds, etc. As a case in point, a highly successful farmers' co-operative society was

organized in Iowa with a capital not to exceed $25,000, shares $10 each, no member being permitted to own more than ten shares. From a business of $220,000 in 1895, transactions of this society increased in five years to $625,000. The plan is to pay farmers just as much for their product as possible, and sell them needed supplies as cheaply as possible.

The officers include a business manager who cannot assume indebtedness exceeding two-thirds of the shares of stock actually paid up. Money can be borrowed on a two-thirds vote of the officers and directors, but the amount must not exceed $5000. Selling members always receive one-fourth cent per bushel more for grain than non-selling members. If a member desires to sell corn to an elevator competing with the society's plant, he must pay the society one-fourth cent for each bushel sold to the competitor. For example, the farmers' elevator is paying thirty-one cents for corn, and the competing elevator offers thirty-three cents; the members sell to it, and after paying the society one-fourth cent are still one and three-fourths cents ahead. This feature alone has prevented competing elevators from coming in and paying high prices for a considerable time until the farmers' elevator is forced out of business. The one-fourth cent meets all the running expenses.

CHAPTER XIV

Corn Pests and Diseases

SO far as the writer has been able to find out by careful examination of records and observation, two hundred and nineteen species of insects have been recognized and recorded as in some way being injurious to some part of the corn plant. For the sake of convenience, these have been arranged according to their attacks upon the various parts of the plant. For instance, eighteen are known to infest the seed; twenty-eight have been discovered upon the root and underground parts of the stalk; seventy-seven have been recorded as injuring the stalk above ground; one hundred and nineteen attack the leaf; nineteen are known to injure in some way the tassel and silk; forty-three work upon the ear in the field; two have been found upon stacked fodder; and twenty-five others in corn in store or in manufactured products. Many of the species recorded in this list are of minor importance, and only the primary ones, found more or less injurious to the corn plant every year, are here considered.

Perhaps the most serious injury to corn occurs when insects attack the seed and the root. This usually happens early in the season, but fortunately for farmers, much of this damage can be prevented by precautionary and preventive measures at the proper time. The following practical hints, as a brief introduction to this chapter, will assist the average person in recognizing the insects responsible for injury to corn either in the field, in store or in the manufactured products.

1—Many farmers attribute the failure of corn to come up promptly to poor seed, if it does not appear in due time under favorable conditions. A careful examination of the seed itself should be made for evidences of injury by wireworms, seed corn maggots, etc, all of which do much damage frequently to seed after it is planted.

2—At times young plants make a very unequal start. Some hills will appear early and grow rapidly,

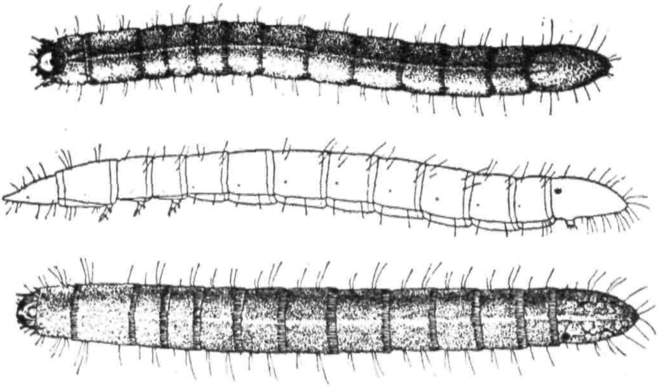


Fig 59—Forms of Wireworms

(Adapted from drawings by Forbes)

while others are dwarfed and make no perceptible growth. In such cases the roots should be searched for the presence of the corn root louse. Very often this insect attacks the sprouting plant before the leaf shows above the ground. The presence of numerous large brown ants in the corn land often burrowing in the hills is also evidence that plant lice are at work at the roots. At other times the corn may be retarded in large patches, the leaves turning yellow at

first and a little later taking on a reddish tinge. In such cases a careful digging up of the hill will probably reveal the presence of root lice. If none are found the difficulty may be attributed to a fungous disease known as the root blight of corn which has no connection with insect injury.

3—Sometimes all the stalks in the hill are colored and wither when a foot or less in hight. This condition usually follows injury by wireworms and white grubs.

4—When the corn falls over easily with a slight wind storm and does not rise up again in due season, one should be suspicious of the presence of the corn root worm, as well as injury by white grubs.

5—Where the corn remains green too long, matures slowly, with many sterile stalks, and contains imperfect nubbins and ears, in all probability the common corn root worm will be found in abundance among the roots, if careful examination is made late in August or early September. In such cases large numbers of green beetles about the size of the common ladybug may be seen at work upon the silks and tassels and even upon the pollen collected at the base of leaves. They are also found upon the blossoms of ragweeds and other flowering plants in the field. These are the adults of the corn root worm, and such fields should not be replanted to corn the following year.

6—Frequently young plants will have the terminal leaves dwarfed and curled so that the growing tips are shriveled. Occasionally the foliage is deformed and of unequal growth, especially the unfolding of the leaves from the roll at the terminal. These are more or less injured, giving the ragged appearance. Damage of this kind usually occurs when the corn is about two feet high and is the work of the first

generation of the corn worm, while later, the second generation is found in the ends of the ears doing serious harm late in the summer and early fall.

7—Sometimes a series of shot holes are found extending across a well-developed leaf. The holes are usually elongated and arranged side by side quite regularly, and are usually the work of one of the corn bill bugs.

8—Sometimes the leaves of young corn are irregularly eaten away, many of them having a gnawed appearance at a time when the stalk is less than a foot high. In such instances usually fine particles and small lumps of earth at the base of the plant will be found closely webbed together in a mass usually about the size of an ordinary walnut. Such condition is the result of the work of the root web worm.

9—The work of the ordinary cutworm is well known to most farmers. The young corn is usually cut above and below the surface of the ground and examination usually reveals the culprit hidden in the ground not far away.

10—If the stalk has a small hole with brown, moist powder exuding from it, it is sufficient evidence that the cornstalk borer is at work within. These creatures do great damage to young corn in the spring, especially on low ground.

11—When an ear is found with the end eaten and burrows leading into it from the tip toward the base, the destructive corn worm can usually be found. Its burrows are usually filled with excrement, discoloring and injuring the ears to a considerable extent, while they are in the soft stage.

12—Injury by grasshoppers is not uncommon, and often the entire leaf is eaten, leaving only the midrib, while others are gnawed and filled with irregular holes, giving them a very ragged appearance.

13—If the corn in the granary loses materially in weight and is filled with small holes, the indications are that it has been injured by the grain moth, or weevil. Very often the presence of these pests can be ascertained by the sawdust-like siftings which accumulate in the lower part of the bin or crib where they are abundant.

14—In corn meal and other manufactured products, the Indian meal moth can be ascertained by the presence of the young worms and the matting together of the meal with small particles of silk spun by the larvae or worms. A large number of moths flying about the pantry, mill, granary or other places where corn products are stored, is usually sufficient evidence that the products are infested and should be looked after without further delay.

THE SEED IN THE GROUND

Wireworms—The most important of all insects that injure seed corn in the ground are wireworms. If the seed fails to start or there is a sudden withering of the corn plant when a foot or two high, especially if the field was in grass one or two years before, there is reason to warrant a suspicion of injury by wireworms. In fact, these hard, smooth, shining, yellowish-brown, cylindrical, six-legged worms are much more destructive to seed corn under ground than all other insects taken together. They sometimes begin their injuries to the seed immediately after planting. They bury their heads in it at first, after eating entirely through the kernel, occasionally devouring it completely. If they attack the growing plant they are likely to eat the smaller roots, or to penetrate or bore through the larger ones, dwarfing or killing the corn. Later when the young plant is several inches high, they frequently kill it outright by boring their cylindrical

channels directly through the underground part of the stalk. They are common in corn on ground which has been in grass for several years. Usually they are much more likely to do serious damage the second year after the breaking up of the sod. They should be looked after on such lands whenever the seed fails to grow, or when the sudden withering of the plant suggests injury to it underground. Under such circum-

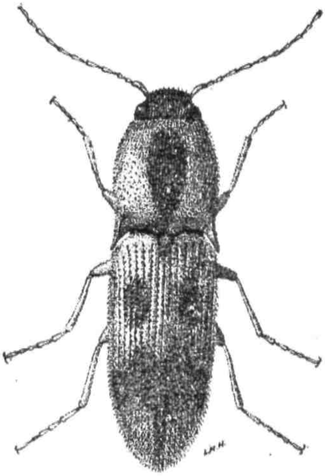


Fig 60—Parent of Wireworm
(After Forbes)

stances practically all the wireworms in the field will be found in the hills. It is not unusual to find ten or a dozen in each hill.

The corn wireworms have a strong family resemblance and are not likely to be confused with other insects. They vary in length when full grown from half an inch to an inch and a quarter, but agree in their hard, crust-like surface, nearly destitute of hairs; their brownish color, varying from yellowish to reddish;

their slender bodies, distinctly segmented and of about equal diameter throughout their length. They live mostly in grass lands, feeding largely on the roots. Their numbers in such places are rarely sufficient to produce any notable effect upon the sod. It is only when concentrated in the comparatively scanty vegetation of a field of young corn in spring, or occasionally in young wheat or other small grain, that they do any very great harm. The commonest form of attack on the corn, as seen by the farmer, is the burrowing of the worm into the kernel. Frequently attacks in the field have been so severe, particularly the first and second years after the sod has been broken, as to require planting a second or third time.

These pests agree fairly well in their life history. They change to the dormant pupae in the earth in July or sometime in August. Some three or four weeks later they transform to the brown or reddish beetles known as "click beetles" or "jumping jacks." They are easily distinguished by their peculiar habit of springing into the air with a sudden click when placed upon their backs. A large part of these fully developed beetles remain under ground until spring. Some of them come out of the ground in the fall and pass the winter in sheltered places; the remainder emerge in spring, laying their eggs mostly in grass lands. Of their subsequent life history little is definitely known.

No class of insects has had prescribed for it a longer list of artificial remedies than the wireworms, yet none of them is of practical value. Their injuries continue practically unchecked. Even poisons of the most deadly sort applied to corn previous to planting, on food lures distributed through the ground, for the purpose of drawing off the attention of these insects from corn, have proved almost entirely valueless, both in the experience of Professor Forbes and in

the most elaborate trials made by Professors Comstock and Slingerland. Late fall plowing, breaking open the pupal chambers, will probably diminish the number of these beetles during the following year. Professor Forbes has suggested a systematic rotation intended to interpose between grass and corn a crop not vulnerable to the wireworms. Otherwise we are substantially without a hint of any means of diminishing the ravages of these insects other than the time-honored resource of the corn farmer, namely, late planting of his corn the second year after sod, and late replanting if the first planting is destroyed. In the latter case it is well to plant between the rows, allowing the first corn to stand as long as is consistent with a proper cultivation of the field. All the wireworms being at the time concentrated on the old hills, if these be destroyed, when the field is planted the second time, the wireworms still active in the earth are forced to attack the freshly planted kernels as their only food resource.

Even a clean fallow for an entire season will not starve out the worms and neither buckwheat, mustard, nor rape crops, frequently recommended to clear the earth of wireworms, will accomplish the desired result. Salt applied at the rate of sixteen hundred pounds per acre, a heavy dressing, neither drives the wireworms deeper into the soil nor causes them to migrate to any appreciable distance. Kainit used as a fertilizer in very large quantities has little effect if any on the worms. The same may be said of muriate of potash, lime and chloride of lime. Gas lime is capable of destroying the worms but has to be applied in such large quantities as to be impracticable on large areas. The most promising method for relief is crop rotation, in which clover follows grass and is itself followed by corn. According to this plan pastures and meadows

of grass might lie unchanged for several years, being plowed when broken up in late summer or early fall and sown to clover in the spring, either with oats or on winter wheat or rye sown the fall before. The clover should be allowed to stand a second year, and might be followed with corn, with positive assurance that the wireworms originally in the sod would by that time have entirely disappeared.

Seed Corn Maggots—Two somewhat common injuries to seed corn in the ground are due to small white maggots without legs, one apparently headless, with much the form and general appearance of a very small blowfly larva, and the other with a smooth, conspicuous head of a shining jet black color. The first is called the seed corn maggot and infests corn only, so far as is known. The second is the black-headed grass maggot, injuring corn only when it follows grass. Both these maggots penetrate the kernel, feeding on the mealy inner part, leaving the outer shell. The former transforms during the summer to a small two-winged fly similar in form to the house fly. The latter becomes a slender small black gnat, somewhat resembling the mosquito. The fly is not likely to be noticed, but the gnat of the grass maggot is often seen in large numbers near the ground in early spring. The seed corn maggot penetrates the grain commonly after it sprouts but before it appears above ground, killing the germ or the growing shoot and finally hollowing out the interior so as to leave only the harder outer part of the kernel. Unsprouted kernels softened by lying in the earth are also frequently penetrated in a way to destroy the germ, as shown in the illustration (Fig 61). The adult is a small two-winged fly, about a fifth of an inch long, and not unlike a house fly in general appearance. There is evidence that only a single brood a year occurs.

When the spring is cool and wet after corn planting, so that the softened seed lies long in the ground without sprouting, it is especially liable to certain kinds of injury, and it is under these conditions that the black-headed maggot seems most likely to affect it. Rotting grain is undoubtedly preferred. It has occasionally been seen to infest kernels that had begun to grow. It lives normally in old sod, feeding chiefly on decaying vegetation there, and will be found in noticeable numbers in corn fields only where the field was in grass the preceding year. These maggots penetrate and hollow out the kernel, often leaving nothing more

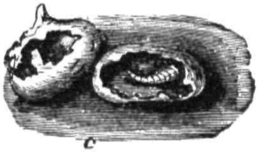


Fig 61—Seed Corn Injured by Seed Corn Maggot
(After Forbes)

than an empty hull. Several of them may infest a single grain. They are slender, footless white maggots, except that the head is jet black, about one-third of an inch long when full grown and of nearly uniform diameter throughout. The body is soft and flexible and the movements of the maggot are sluggish. The species is very common.

In his observations, Professor F. H. Chittenden of the United States department of agriculture says that one of the best means of deterring the parent flies from depositing their eggs consists in sand soaked in kerosene, one cupful to a bucket of dry sand, placed at the base of the plants, along the rows. This also kills young larvae that might attempt to work through the mixture. Fertilizers, preferably kainit and nitrate

of soda, are also useful as deterrents, particularly when employed just before or after a shower has thoroughly wet the ground. They should be applied as nearly as possible to the roots, and the earth should be turned away from the plants for this purpose. This remedy has the advantage of acting as a fertilizer as well as a preventive of insect attack. As soon as plants show signs of wilting, and this maggot is known to be present in the field, the injured plants should be promptly pulled and destroyed. These methods of control have been used with success against onion maggots and similar root-feeding species.

The White Grub—Injuries of white grubs to corn may begin as soon as the roots are fairly well started, and will range according to the age of the plant, kind of weather, and the age and abundance of the grubs. There may be only a slight and temporary retardation of growth but a complete destruction of all the corn is not uncommon. Loss of the tap root exposes the plant to severe suffering by early drouth, and it is often so reduced in vigor from root injury that it fails to form brace roots at the proper time, and hence has so slight a hold upon the earth that it cannot keep itself erect or recover itself after prostration. In any case where the plant is yellowed, or dwarfed, or killed outright, especially if these appearances be most marked on the higher, lighter parts of the field, the presence of white grubs may be suspected. As the roots of an infested plant are evidently eaten away, injury by the white grub is not easily mistaken for any other. The presence of the insects themselves, in the earth among the roots, is not hard to detect. If they are not thus found where other evidence points to them as the cause of the injury, they may frequently be discovered by digging down a foot or two in the worst injured tracts.

The adult beetles of the more abundant forms spend the winter in the earth in cells where they originated, emerging in spring and early summer. Warm and genial days in spring often bring them suddenly out in myriads where previously only scattered individuals have been seen, and their flight at night is free when the weather is warm. The grubs feed only during the season of growing vegetation, usu-

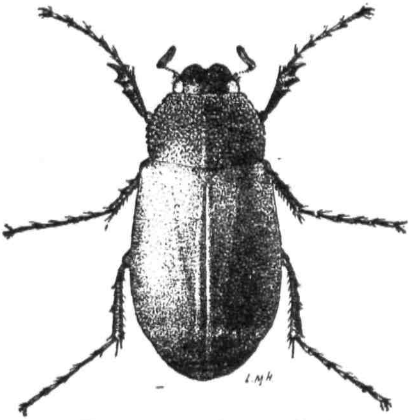


Fig 62—Adult of White Grub
May or June beetle, male; enlarged (after Forbes)

ally going down into the earth from the middle to the last of November to a depth varying according to the severity of the winter weather, and coming up again within reach of food commonly sometime in March or early April. Full-grown white grubs will live an active life in the earth, feeding freely from March to June or July, during which months they change to the pupa a few inches under ground in oval cells. At least some species of the white grub may be freely and abundantly bred in fields

of corn; but it still remains true that by far the greater number of those in the country at any time have arisen from eggs laid by beetles in ground bearing a crop of grass; and that corn is consequently much more likely to be damaged if planted on sod than if it follows clover, small grain, or corn itself.

The first effort of the corn farmer should be directed to clearing the grubs out of the grass land which he wishes to plant to corn. For this purpose Professor Forbes thinks that hogs should be pastured for a considerable time on the meadows or pastures before plowing for corn, and that they should also be

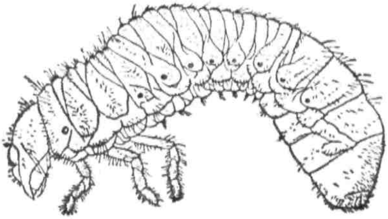


Fig 63—White Grub
Young of the June beetle; enlarged (after Forbes)

given the run of the field while it is being plowed. This measure will be practically useless under ordinary circumstances, if resorted to later than October or earlier than April. In the interval between these months the grubs will be beyond the reach of pigs, buried in their winter quarters. After plowing, the collection by hand of white grubs may be resorted to where they are particularly abundant, especially where any kind of cheap labor may be had. Owing to the relatively small damage done to clover by the grubs, it is a good practice to insert clover between grass and corn in the rotation; and this is especially advisable in light soils not perfectly adapted to corn. Here it

will have the effect of not only eliminating the grubs, but will also diminish the damage to the following crops of corn by increasing the strength of the land, thus helping the corn plant to withstand such loss of roots as it may be subjected to. Generous treatment of the soil by heavy fertilization, thorough cultivation, and the like will diminish loss to corn by enabling plants attacked to throw out new roots. The man-

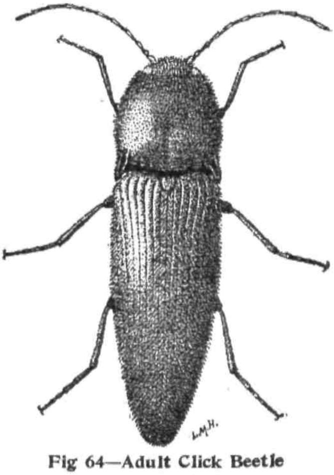


Fig 64—Adult Click Beetle
(After Forbes)

agement of corn on land containing grubs should also be directed to the protection of the plants from drouth, as dry weather takes a double effect by retarding root growth.

To prevent the laying of the eggs of the June beetle in the corn field in May and June, it is desirable that the ground should be kept practically free from weeds at that time, as it is well known that a surface growth of vegetation is a strong attraction to

these insects searching for places suitable for the support of the young. Professor Forbes says direct remedies for the attacks of white grubs are either inapplicable to the corn field, are of doubtful economic value, or are too little understood, as yet, to make them worthy of recommendation. For example, kerosene emulsion may properly be applied to infested lawns, and, if followed by a copious watering, may kill large numbers of the grubs, but the cost of the material and treatment will preclude its use against grubs in corn;

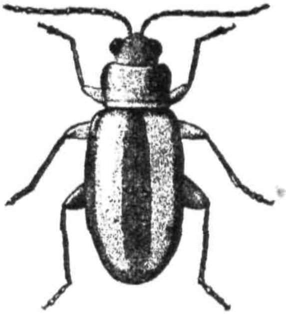


Fig 65—Pale Striped Flea Beetle
(After Chittenden)

and kainit and other potash fertilizers will destroy grubs in the earth, but for this purpose must be used at a rate inadmissible in farm practice.

The southern corn root worm will probably be found much more generally present in corn fields than indicated by reports. Its injuries are very similar in general character and effect to those of the much more abundant and better known northern corn root worm, mentioned below. The presence of this root worm in the field gives origin to the usual general effects of the loss of roots by the plant, varying according to the age

of the corn, the gravity of the injury, kind of soil and weather. In the young plant about six inches high, the characteristic perforations of the stalk underground may result in the sudden withering of the whole plant, or more commonly, in the killing of the central leaf or tuft of growing leaves—an appearance which has given to this insect the common name of the "bud worm" in some of the southern states. In certain instances the plant has been killed, as the writer observed in Maryland, almost as soon as it was sprouted.

As the season advances the corn in the affected fields is likely to be uneven, and later, as the plant becomes topheavy with growth, it may fall when the

Fig 66—Southern Corn Root Worm
Dorsal view; enlarged five diameters (after Forbes)

soil is softened by rains, especially during storms. Having once so fallen, it will, if badly injured, fail to rise again; and it may further be seen that the plant has but little hold upon the ground, a whole hill, perhaps, being readily pulled up with one hand. As a consequence of the loss of roots and the general weakening of the plant, many stalks fail to set the ear, or form only a nubbin. The injured plant also matures slowly, remaining green longer than the average, and being thus especially subject to injury by frost. A closer examination ot the young plant will commonly show a perforation of the underground part of the stem either at or near the upper circle of the roots. Later, as the plant increases in size, the roots themselves are seen to be gnawed irregularly, great holes or

notches being eaten out, first in one direction and then in another, until the roots are severed or consumed. In the larger roots the larva may perhaps completely bury itself. In well-grown corn it very commonly bores into the stalk beneath the upper circle of brace roots, or behind the sheath of the lower leaf, in which habit it differs from the northern corn root worm. It is a soft, slender-bodied, worm-like insect, a little over

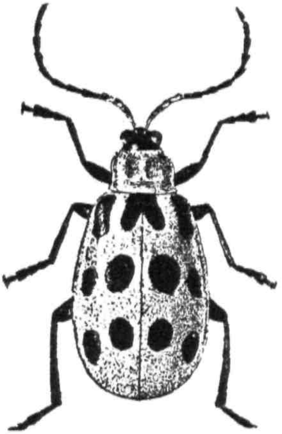


Fig 67—Beetle of Southern Corn Root Worm
Enlarged five and two-thirds diameters (after Forbes)

an inch long when full grown, and nearly ten times as long as thick.

The fact that its injuries to corn occur without apparent reference to the crop of the previous year makes it unlikely that the favorite method of rotation will serve for the protection of corn against this species. Sweet corn seems to be much more liable to injury than the field varieties, from which fact we may surmise that the time of planting has something to do with

the intensity of the attack. The vicinity of cucumbers, squashes, and other of the commoner food plants of the beetle may account for this seeming preference.

Northern Corn Root Worm—It is not an uncommon thing for the farmer to find his corn wilting and falling over very easily during the months of June and July. He wonders why it does not take root. The fact is the roots have been destroyed by a slender white worm not thicker than a pin, about a quarter of an inch long, with a small brown head and six very short legs. It begins its attacks on the roots in May and June, eating its way beneath the surface, and killing the root as fast as it grows. Late in July or early August the worm settles near the base of the hill, where it transforms. In a few days a bright grass green beetle emerges, scarcely more than a quarter of an inch long. It climbs up the stalk and feeds on the fine yellow dust or pollen and upon the fresh silk at the end of the ear; when the silk dries out, some of the beetles creep down between the husks and feed upon the corn itself, while others fly to such weeds as are in blossom.

The female lays its eggs in the ground in September and October upon or about the roots of corn. The beetles die late in the fall. The eggs remain in the ground over winter and do not hatch until after the ground has been plowed and planted to corn in the spring. The principal injury is done by the worms in their attack upon the roots; but some harm is done by the adult beetles, when numerous, by eating the silk before the kernels are fertilized by the pollen. They also occasionally destroy a few kernels in the tip of the ear. Although the roots penetrated by the worms die and decay, thrifty corn will throw out new ones to replace those lost, and this is most likely to occur in moist rich ground in wet seasons. The damage is therefore greatest on high ground and in dry weather,

and the use of manure will palliate, but not wholly obviate the injury. Little or no mischief is done except in fields that have been in corn during the year or two preceding, and a frequent change of crops is therefore a complete preventive.

STALK AND LEAF

Cutworms—Corn growers for many years have suffered serious annual loss from the ravages of cutworms. These losses are becoming more apparent in sections where crimson clover and other crops are grown on the corn lands for turning down in the spring as a soiling crop. Such fields furnish ideal places the early and latter part of the season for the parent insects to deposit their eggs and for the young worms to feed. The result is that when the crop is turned under the worms remain below the ground for a time feeding upon the leaves, stems and roots until the corn is up, and then they emerge and concentrate upon the delicate plants. In many instances the second planting is cut off.

The parent insects or moths of the common cutworms vary greatly in color in the different species. Normally the female lays her eggs in grass lands, but clover fields and weedy places get their share. The young worms hatching from these eggs early in the summer or late fall, feed voraciously upon any vegetation in their vicinity and are by no means particular what it is; the only requirement being that the plant shall be juicy and abundant.

It is known that cutworms as well as the adult moths have a liking for sweet substances, and are attracted to them when they are placed in their vicinity. The worms also eat wheat bran with much relish. By combining bran with molasses, or syrup made from sugar, we have an ideal bait, and the worms will eat it

in preference to anything else when available. By poisoning this material with paris green or arsenic, we have a good remedy, cheap and easy to apply.

The ingredients used for making the poison mash are as follows: Wheat bran, fifty pounds; molasses (any kind), two quarts; paris green (good quality), one pound; and water (enough to make thick mash). The bran should be placed in an old tub or barrel, and to this the poison should be added and stirred thoroughly before the water or molasses is poured in. Stir the molasses in about a gallon of warm water and pour it over the bran, to which the poison has been previously added, thoroughly stirring until it is well mixed. Then add enough water to make a mash about the consistency of dough, so that it can be handled easily without running. Drop a small quantity near each hill. Not over a heaping teaspoonful in a place. Apply in the afternoon toward evening. Where it is necessary to get over large areas, there is no objection to distributing it in any time during the day Care should be taken to keep chickens, turkeys, or animals of any kind that would be liable to eat the mash, out of the field for a day or two. A light cultivation a few days later will cover up any remnant that may be left.

The Army Worm—The popular name is given to this creature from the fact that the worms congregate and travel in large numbers, invading a field of corn or other crop like an army. The sudden appearance and disappearance of this pest is very curious. The adult moth appears in the fields early in the spring. Two or three days are required for the moth to complete the egg laying process, after which it dies. Eight or ten days elapse before the eggs hatch. The young worms begin to feed at once. When not excessively abundant they hide during the day and are rarely seen. In years of great abundance they are generally unno-

ticed during the early life. The earliest acquire full growth and commence to travel in armies and devastate fields of corn and other crops. They soon afterward descend into the ground, where they transform and issue again as moths two or three weeks later.

Fig 68—The Army Worm

Full grown larva; natural size (after Comstock).

The advance of these creatures can be arrested by ditching. To protect a field, however, from the marching horde, a deep furrow should be plowed along the side toward which they are moving, care being taken that the land-side is next the threatened crop. The worms being unable to climb this, accumulate in the furrow, where they can be trapped in post holes dug every ten or fifteen feet, and killed with kerosene, crude petroleum, or by crushing. Planks or boards of any kind placed on edge end to end and smeared with coal tar will prove an effectual barrier to them. Paris green, london purple, or better, arsenate of lead, sprinkled on the plants in front of a marching host, can be used to good advantage. The most important agents which keep these pests in check are insect parasities, which attack the worms in great numbers when they appear in marching armies. These parasites develop so rapidly it is not an uncommon thing at times to find two-thirds of the worms parasitized.

The Larger Cornstalk Borer—In general appearance it is a white six-footed caterpillar, ordinarily with dark-brown spots, boring into the stalks of young corn, causing more or less distortion of the plants, and seriously reducing the yield. The larva bores into old stalks, later working down into the tap root and passing the winter in a channel near the surface of the ground or a little below, transforming in the spring to a brown moth. This insect is thought to be identical with the sugar-cane borer of Louisiana and the West

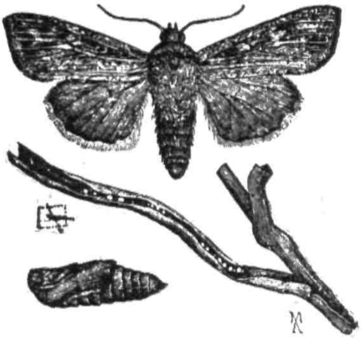


Fig 69—The Army Worm

Moth above, pupa below, and eggs in natural position in a grass leaf—all natural size (after Comstock)

Indies. It occurs all through the southern states, west to Kansas, and as far north as Maryland along the north shore of the Potomac river. The adult insect issues from the old cornstalks in the spring. Soon after the young corn comes up it lays its eggs upon the leaves near the axils, and the larva upon hatching penetrates the stalk at or near the joint and commences to tunnel, usually upward through the pith. When ready to transform it bores to the surface of the stalk, making a hole for the exit of the future moth, then

changing to the pupa state. The damage done by the second generation consists largely in weakening the stalk so that it is readily blown down. Injury by the first generation results in serious harm to the crop, preventing the growth of the ears. Upon reaching maturity, the larvae of the second generation do not transform at once, but the majority of them pass the winter as larvae. Early planted corn is more apt to be infested than late corn. For instance, corn planted

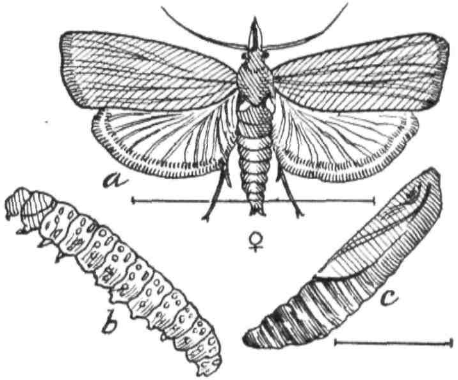


Fig 70—The Larger Cornstalk Borer

a, female; *b*, larva; *c*, pupa—all somewhat enlarged

the first and second weeks in April, twenty-five per cent was damaged; the third and fourth weeks, twenty per cent; May 1 to 15, fifteen per cent; of that planted May 15 to 31, twelve per cent; June 1, eight per cent. In fact, corn planted after June 1 was practically uninfested. See Fig 88, showing work of the larger cornstalk borer.

With the more careful and thorough methods of cultivation in the North this insect in all probability will not thrive. Dr L. O. Howard, entomologist of

the United States department of agriculture, thinks it will reach its maximum in localities like parts of South Carolina, where corn is simply stripped for fodder in early August, and the bare stalks with the ear attached stand until after the cotton is picked, ginned and shipped, and where even after the ears are harvested the stalks are seldom burned. In Virginia, however, the conditions are nearly as favorable for the continuous development of the insect. Where it is not intended to follow corn with winter grain, the corn is cut in October and the butts stand in the ground until the following spring, affording the larvae safe places for hibernation. Even in plowing for another crop of corn in the spring many of the old stalks are not destroyed, but still remain standing through winter. Under these conditions there is no check whatsoever to the increase of the pest. Where winter grain follows corn, the stalks are not thoroughly dragged off. Even when collected they are rarely ever burned. Where the old stalks are systematically removed from the field and burned after the harvest or during winter, or where a constant rotation of crops is practiced, the cornstalk borer will never become a serious pest. Southern farmers have it in their hands to check it at any time by pursuing these methods. Aside from corn, sugar cane and sorghum, this borer has only one other food plant, so far as is known. This is the gama grass, or sesame grass, *Tripsacum dactyloides*, which grows very high in swampy ground. Farmers whose corn fields adjoin swampy ground should burn over the grass during the winter. The rotation of crops is reasonably efficient against this insect.

The smaller cornstalk borer is a tropical species occurring in Alabama, Georgia, North and South Carolina, Florida, Kansas, Texas and as far north as

Virginia. It also inhabits Central and South America. The moth has been captured in Maryland and Indiana, but this is not evidence of the permanency of the species in those states. As this stalk borer hibernates in all stages, larva, pupa and adult, a practical remedy is difficult to find. The pulling up and burning of infested material as early as possible after the crop is removed, and rotation with some crop that would not be affected by this species, are desirable. It is quite a serious pest on beans and peanuts occasionally,

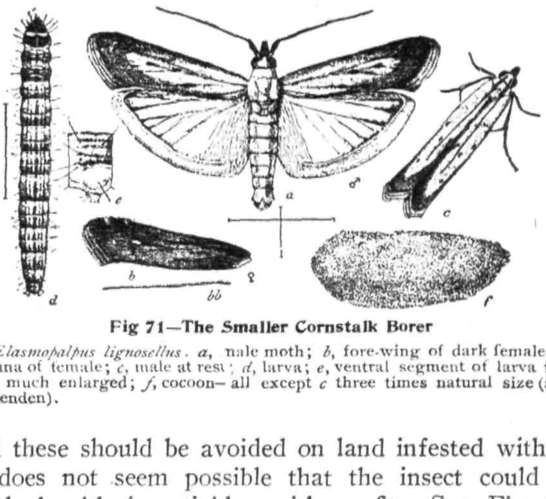


Fig 71—The Smaller Cornstalk Borer

Elasmopalpus lignosellus. *a*, nale moth; *b*, fore-wing of dark female; *bb*, antenna of female; *c*, male at rest; *d*, larva; *e*, ventral segment of larva from side, much enlarged; *f*, cocoon—all except *c* three times natural size (after Chittenden).

and these should be avoided on land infested with it. It does not seem possible that the insect could be reached with insecticides with profit. See Fig 92, showing work of the smaller cornstalk borer.

The Corn Worm—The corn worm has about as many popular names as it has food plants. Throughout the corn growing states it is known as the corn worm when it occurs upon corn. In the cotton growing states it is called the boll worm when found upon cotton. In many southern states it is known in the

early part of the season as the corn bud worm. The same worm is found also upon tomatoes, and is called the tomato worm. It is about an inch and a half long when full grown, and varies in color from pale green to dark brown, with longitudinal stripes of the same color. This difference in color is so great as to make them look like different insects; still the markings are the same; the green worms marked with stripes of darker green, and the brown ones with darker brown. When full grown they leave the ears and crawl into the ground, when they change to chrysalids. See Fig 84.

There are as many as five broods during a single season in Alabama. There are three normal broods a year as far north as New Jersey, Ohio and northern Illinois, then in South Carolina, north Georgia, Tennessee and Arkansas there are probably four broods, and as many as six in south Texas and Florida. Early in the spring, pale, clay yellow moths, with a greenish tinge, emerge. They are very seldom seen, unless disturbed during the day, when they fly out with a quick, darting motion.

The eggs of the first brood are laid upon the leaves of the corn, upon which the young begin to feed as soon as hatched, gnawing many small, irregular holes through them, giving them a ragged appearance. The brood that works on the ears is produced from eggs laid on the silk; and when hatched they feed upon the silk; when they come to the kernels, they work their way around the ears inside the husks, sometimes eating only the outside portion of the kernels, or boring through the under side next to the cob, so that when the husks are stripped back the worm may be nearly half hidden in the corn. As the corn gets hard, those that are full grown leave the ears and go into the ground to undergo their transformations, while others

that have not reached that stage die and rot in their burrows, where they mold and decay, making the corn unfit for use.

In garden patches of sweet corn, hand picking is the best remedy so far suggested. The planting of several rows of early sweet corn around the field liable to be infested has been advised. In such cases the moths are attracted to these rows of early corn and deposit their eggs, after which the worms can be hand picked, or destroyed by the destruction of the corn. Fall plowing will also break up and expose many chrysalids.

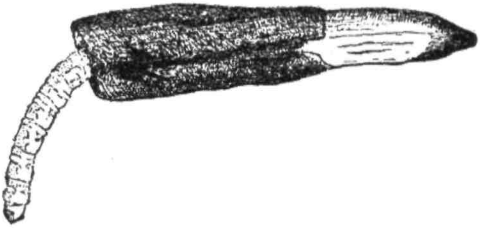


Fig 72—Corn Root Broken Across to Show Northern Corn Root Worm Within

(After Forbes)

The Chinch Bug—As soon as wheat is cut the chinch bug usually makes its way on foot, for it rarely uses its wings, to the nearest corn field. It is not an uncommon occurrence in the central western states to see the ground literally covered with these bugs in their various stages of development, passing from one field to another. If the ground is reasonably dry several furrows should be plowed around the field of corn. After harrowing and pulverizing as much as possible, open a furrow six to eight inches deep with a single shovel plow. In this drag a smooth log eight to ten inches in diameter until the furrow is

finely dusted on both sides. If necessary make several parallel furrows in the same manner. The bugs tumble in them and are unable to crawl out on account of the dust crumbling under their feet. If the sun is hot the bulk of the pests are destroyed; but in cool weather it may be necessary to drag the log back and forth several times during the day to destroy them.

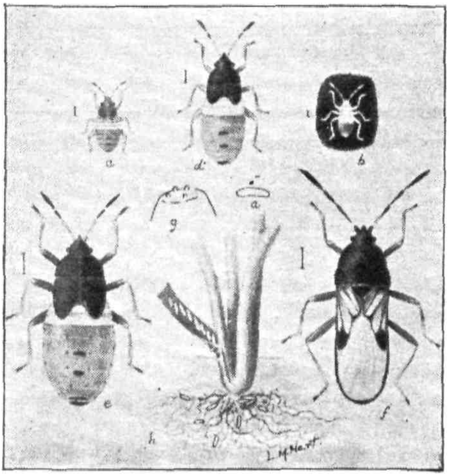


Fig 73—Various Stages of the Chinch Bug
(After Johnson)

When the ground is too wet to make furrows, gas or coal tar can be used. It should be poured in a continuous stream on the ground, forming a band about half an inch or more in width. The bugs will crawl up to this line, but will not cross it. They will run in either direction along the line, and can be trapped by digging post holes every few rods. Care must be taken to see that no rubbish, not even a straw

or blade of grass, forms a bridge over the line. In case the bugs do get upon the young corn they can be destroyed by spraying with a ten to twelve per cent solution of kerosene emulsion. It should be applied with a good spray pump. About one-quarter to half a pint of emulsion will be sufficient for each hill. In 1895 the writer made a practical demonstration of these methods on the farm of William Quade near Edgewood, Illinois. A forty-acre field of corn surrounded on three sides with wheat and oats was saved. In one day it was estimated that the furrows contained about twelve bushels of dead chinch bugs.

The Corn Root Aphis—Usually associated with ants in hills of corn, farmers will often find minute, soft, thick-bodied, six-legged insects, mostly without wings. They are always sluggish. When exposed they may show little or no signs of disturbance, but if shaken off the roots into which their lance-like beaks are inserted, they will probably crawl slowly and clumsily about. Ants which have nested in the hill will seize these little insects in their jaws and hurry away with them into concealment. No insect affecting corn is more deserving of the attention of farmers than the corn root aphis or louse. It ranks as a corn pest with the chinch bug and army worm. See Figs 74 and 85.

The corn root louse takes its food through a stiff beak, which it thrusts into the tissues of the plant it feeds upon. It thus produces no external injury, nor any local internal effect discoverable by ordinary methods of observation. Indications of injury by this insect are consequently all of a general character, affecting the entire plant, and do not materially differ from those caused by severe drouth, except in the fact that they are likely to be unequal in different parts of the same field in a way to indicate no connection with the amount of retained moisture in the soil. The

root louse has been found on the plant as early as May 9, only four days after the field was planted.

The dwarfing of the plant, especially in patches here and there, with a yellowing or reddening of the leaves, beginning with the lowest ones, and a general apparent lack of thrift and vigor, are sufficient to cause suspicion of injury by this louse. This will be confirmed in part if numerous burrows of ants are seen in or near the hills. The presence of ants in the field

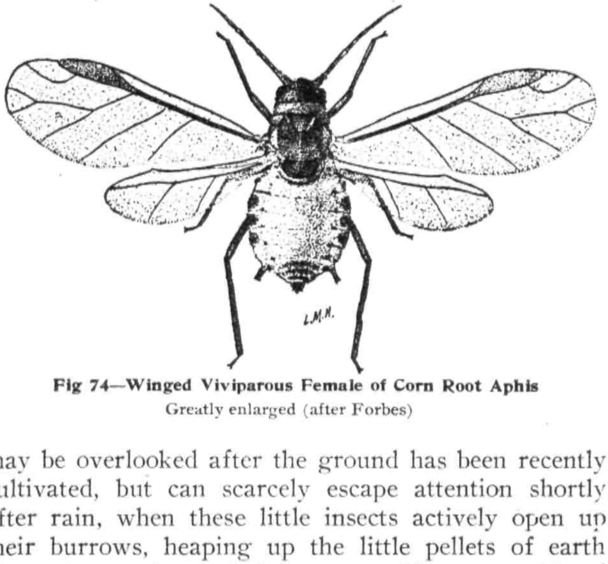


Fig 74—Winged Viviparous Female of Corn Root Aphis
Greatly enlarged (after Forbes)

may be overlooked after the ground has been recently cultivated, but can scarcely escape attention shortly after rain, when these little insects actively open up their burrows, heaping up the little pellets of earth about the openings of their nests. The root aphis of the corn is of a bluish-green color, slightly whitened by a waxy bloom. The form of the body is usually oval, with two short, slender, but conspicuous tubes on the hinder part. These stand erect or project slightly backward, and have open ends externally. They are called "honey tubes," it having been formerly supposed

that they were the source of the abundant excretion upon which the ant attendants of the lice eagerly feed. The grass louse, on the other hand, is white in color, with a blackish head and other blackish markings, but without any tint of green; it has no traces of honey tubes, their place being taken by two minute openings in the corresponding segment of the body, each surrounded by a delicate brownish rim.

From our present knowledge of these pests, there seem to be at least four methods to attack them. Professor Forbes, in summing up the results of work done in Illinois, thinks farmers may (1) try the effect of a change of crop after any notable plant louse injury to corn, in the expectation that corn planted on ground which contains no plant louse eggs will become so slightly or so slowly infested, if at all, that no harm need be anticipated. (2) The application of fertilizers and other materials made to the young corn hill in spring in the hope of killing the lice outright or of supporting the plant against their attack at a time when this is likely to be most injurious. (3) Since the small brown ant cares for the eggs in winter and spring, it is thought the lice can be lessened by disturbing the nests or breaking them up and dispersing their contents in late fall or winter, so that their stores of aphis eggs cannot be recovered by them, and thus left to perish. (4) Taking account of the early hatching of the eggs in spring, several days, as a rule, before the usual time for planting corn, and the dependence of the young lice for food at that time on sprouting weeds in the field, especially smartweed and pigeon grass, the ground should be handled in such a manner that there shall be no sufficient start of vegetation to keep the lice alive. Delay somewhat, if necessary, the planting of the field to corn. There can be no doubt that a

judicious rotation of crops has the effect at least to diminish injury by the corn plant louse by distributing its attack. Many observations show that wheat and oats and the smaller grass-like plants in general are commonly soon deserted by such corn root lice as commence to breed on them.

IN THE BIN AND GRANARY

The grain moth is perhaps the most destructive enemy to stored corn south of the wheat growing belt. Its ravages are most marked in Texas. It attacks all

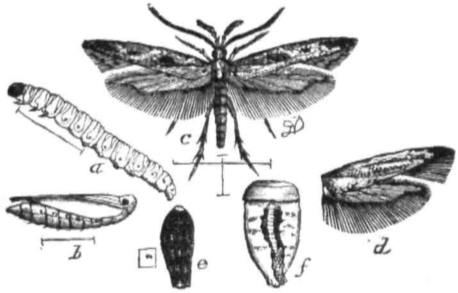


Fig 75—The Grain Moth

a, larva; *b*, pupa; *c*, adult moth; *d*, wings showing marking; *e*, egg—much enlarged; *f*, grain of corn, showing larva at work (after Riley)

stored cereal products, but corn and wheat are the principal grains affected. Its presence in corn can be easily detected. The corn is light and is peppered full of little round holes about half the size of a pin's head.

The parent insect is a small gray moth, resembling a clothes moth, and measures only about half an inch with its wings spread. The moth lays its eggs only upon hard grain. They are deposited in the field, granary, warehouse, mill or elevator. The eggs hatch in about a week and the young worms

work their way into the grain. They feed for about three weeks. The creature passes the winter only in granaries, warehouses, mills or elevators. It will breed uninterruptedly, generation after generation, in stored corn or wheat. After harvest the moth flies out from the granaries to the corn and wheat fields and lays its eggs upon grains of corn and wheat in the shock. The larvae are not destroyed by the husking or threshing, and are carried back to the granaries and finally to the warehouse. When once established in such places, it will remain there an indefinite length of time. The most efficient remedy now known for its arrest and destruction is bisulphid of carbon. It can be thrown directly upon grain without injuring its vitality or edible qualities in the least. See Fig 90, showing ear of corn riddled by the grain moth.

The Grain Weevils—The granary weevil is a small, flattened-snout beetle, less than a quarter of an inch long, of a uniform shining, chestnut-brown color. The larva is legless, short and fleshy, whitish in color. In making preparations for the deposition of her eggs the female first punctures the corn with her snout, and then inserts an egg in the incision. The eggs hatch in a short time and the larva devours the interior of the grain and finally undergoes its transformation within the hull. In wheat and other small grains a single larva inhabits a kernel, but in corn several individuals may inhabit the same kernel. About six weeks are usually required for the transformation from egg to adult. There are probably four or five broods in the northern states, and six or more in the southern. The adult beetles do a great deal of damage by gnawing into the kernels.

The rice weevil, another common species, was first found in rice and was given this popular name by its discoverer. It occurs in every state and territory and

occasionally invades Canada and Alaska. It is most troublesome in the southern states, where it is commonly, but erroneously called the "black weevil." Large cargoes of grain have frequently been destroyed during transportation by this insect. The annual losses by it are very great in India, Mexico, South America and other tropical countries. It resembles

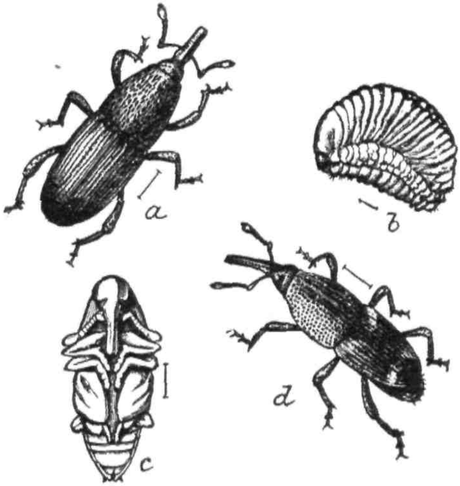


Fig 76—Grain Weevils

Calandra granaria: *a*, beetle; *b*, larva; *c*, pupa; *d*, *C. oryza* beetle—all enlarged (after Chittenden)

the granary weevil in size and in general appearance, but has well developed wings. It is a dull brown and its wing covers are ornamented with four more or less distinct red spots. The larva and pupa are similar to those of the granary weevil. Although the rice weevil feeds upon rice, it attacks a great variety of other cereals, particularly corn and wheat.

There is but one standard remedy for all stored grain insect pests, and that is scrupulous cleanliness supplemented by the free use of bisulphid of carbon. The bisulphid is usually evaporated in vessels containing one-fourth or one-half a pound each, and is applied in tight bins at the rate of a pound to a pound and a half to the ton of grain, and in more open bins a larger quantity is used. For smaller masses of grain or other material an ounce is evaporated to every one hundred pounds of the infested matter. Bins may be rendered nearly air-tight by covering with cloth, blankets or canvas. Infested grain is generally subjected to the bisulphid treatment for twenty-four hours, but may be exposed much longer without harming it for milling purposes. If not exposed for more than thirty-six hours its germinating power will not be impaired. In open cribs and badly infested buildings it may sometimes be necessary to use a double quantity and repeat treatment at intervals of about six weeks during the warmest weather.

For a complete and detailed account of this substance, together with directions for its application in stored corn, the reader is referred to the book "Fumigation Methods," published by Orange Judd Company, New York.

MANUFACTURED PRODUCTS

The Indian meal moth has a wide distribution and does not confine its attacks to grains and farinaceous products, but feeds on seeds and various kinds of nuts, dried fruits, roots and herbs. It is an all-round nuisance in granaries, stores, and in houses. The moths are quite active and are easily disturbed. They may be seen flying about a granary, warehouse or pantry in the daytime, but they are usually more active at

night. The female deposits her eggs upon the grain or in the meal itself, where they hatch in a few days into tiny worms. When full grown the worms or larvae are about half an inch long, flesh colored and hairy. They have the peculiar habit of spinning fine silken threads wherever they go, in much the same manner as the flour moth. When full grown the larvae usually leave their food and crawl to some isolated angle or corner to pupate. They are exceedingly free with their silk during the migratory period, and will often line the inside of tightly closed bins or

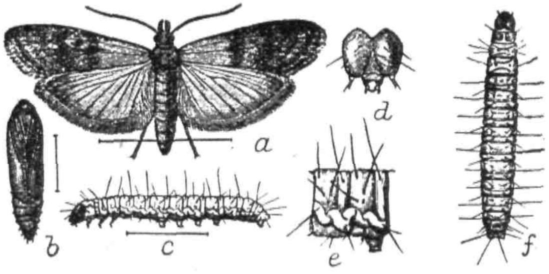


Fig 77—Indian Meal Moth

Plodia interpunctella: *a*, moth; *b*, chrysalis; *c*, caterpillar; *f*, same, dorsal view—somewhat enlarged; *d*, head; *e*, first abdominal segment of caterpillar—more enlarged (after Chittenden).

granaries with their waste material, trailing it back and forth in every conceivable direction, forming a fine and delicate fabric. There are in all probability from five to seven generations annually where the temperature is favorable.

The meal snout moth is another little moth which is attracting considerable attention in this country. It usually occurs in mills, granaries, storehouses, barns and houses where farinaceous products are stored. The adult moth is a beautifully banded creature with a wing expanse of about an inch. The ground color is

light brown, with reddish reflections. The larva is about three-quarters of an inch long, and is considerably darker than that of the preceding species. Its habits are similar to those of the Indian meal moth. The larva constructs tubes of silk and particles of feed or other food in which it lives. It lives on cereals of all kinds and in all conditions, either in the kernel or in the form of flour, meal or bran.

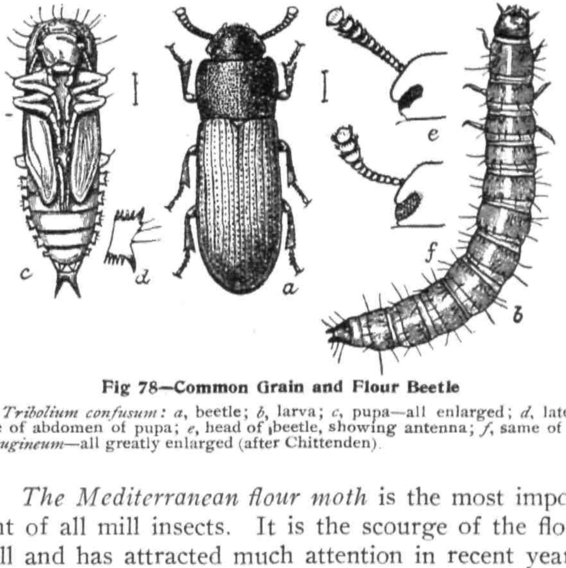


Fig 78—Common Grain and Flour Beetle

Tribolium confusum: *a*, beetle; *b*, larva; *c*, pupa—all enlarged; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of *T. ferrugineum*—all greatly enlarged (after Chittenden).

The Mediterranean flour moth is the most important of all mill insects. It is the scourge of the flour mill and has attracted much attention in recent years. It was discovered in a flour mill in Germany in 1877. In later years it invaded Belgium and Holland, and in 1886 appeared in England. Three years later it made its appearance in destructive numbers in Canada. In 1892 it was discovered by the writer in mills in California and in New York, Pennsylvania in 1895, and recently in Ohio. Indiana and other states. The adult

moth has a wing expanse of a little less than an inch; the fore wings are pale leaden gray with transverse black markings. The caterpillar is whitish and hairy. It is their habit of web spinning that renders them so injurious where they obtain a foothold. It is while searching for a proper place for transformation that the insect becomes troublesome. The infested flour becomes felted together and lumpy, the machinery is clogged, necessitating frequent and prolonged stoppage, and resulting in a short time in the loss of thousands of dollars in large establishments. Although the larva prefers flour or meal, it will attack grain when the former are not available, and it flourishes also on bran, prepared cereal foods, including buckwheat grits and crackers. When a mill is found to be infested, the entire building should be fumigated, and in case a whole district becomes overrun, the greatest care must be observed not to spread the pest. Uninfested mills should be tightly closed at night, and every bushel of grain, every bag or sack brought into the mill, subjected to a quarantine process by being disinfected either by hydrocyanic acid gas or bisulphid of carbon.

THE CORN SMUT

Corn smut is very common throughout the United States and familiar to every cultivator. In ordinary years the yield is decreased by it on the average from a fraction of one per cent to about two per cent, while in exceptional seasons and in particular localities the loss may reach ten per cent, or in rare cases even fifty or sixty per cent. Compared with some fungous diseases of cultivated crops, this is a low percentage of injury; and yet for the whole country it represents many millions of dollars annually. Even for single farms, where corn is a staple product, it is an amount worth saving.

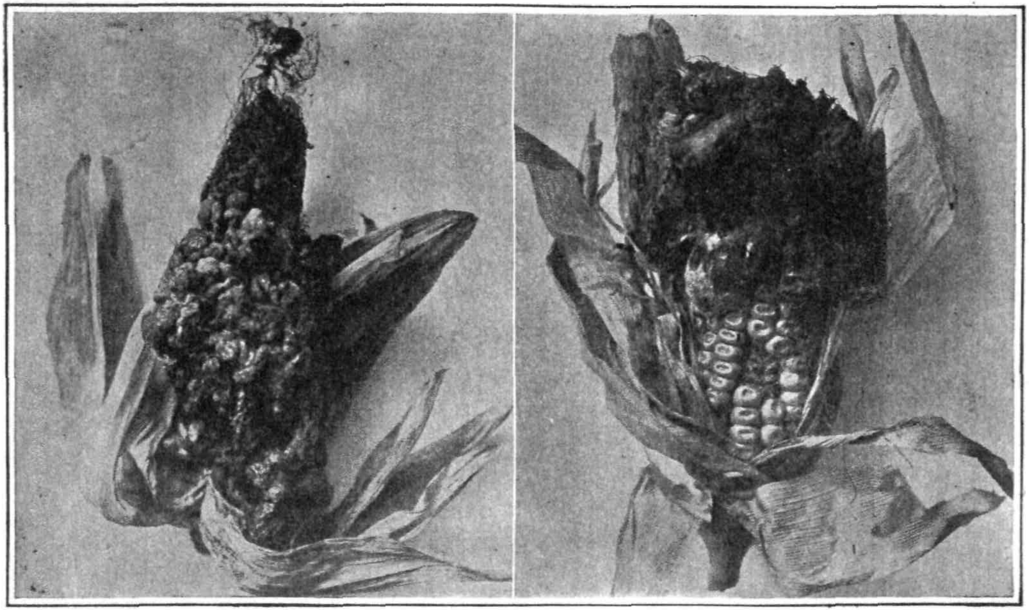


Fig 79—Two Ears of Smutted Corn

Corn smut is caused by a fungus known to botanists by the name of *Ustilago zeae*. It is a fungus of simple structure and habits, entirely distinct from the smuts of sorghum, broom corn, wheat, oats, barley, millet and those of many other wild and cultivated plants. It affects any part of the plant above ground, forming large pustules, at first of a whitish or grayish color, and finally black by exposure of the mass of dark fungous spores. On the left every kernel (see Fig 79) is destroyed, and the growth of the outer part of the ear has been checked by the disease. On the right only the outer half of the ear is affected, the remainder having perfect kernels, unaffected with smut, and which might be planted without danger of transmitting smut to the next crop. From photographs loaned by the Indiana experiment station.

When the corn plant becomes inoculated with the disease, the infection does not spread to all parts of the plant, but remains local, so that each pustule represents a separate infection. The fungus does not grow upon the surface, but inside the tissues, and by the irritation that it sets up causes the tissues to swell and form a pustule, the size depending upon the amount of nutriment that the fungus can extract from the plant, and the rapidity with which that part of the plant is growing at the time. For these reasons the ears usually bear the largest masses of smut.

For one hundred and fifty years or more it has been the practice of farmers in Europe to treat seed wheat with blue vitriol to remove smut from it, and in late years a variety of practical and efficient methods for the treatment of seed grain have come into general use in both Europe and America. Until recently it has been assumed that corn smut might be prevented by similar means, and it was not until the life history of the corn smut fungus was fully worked out by

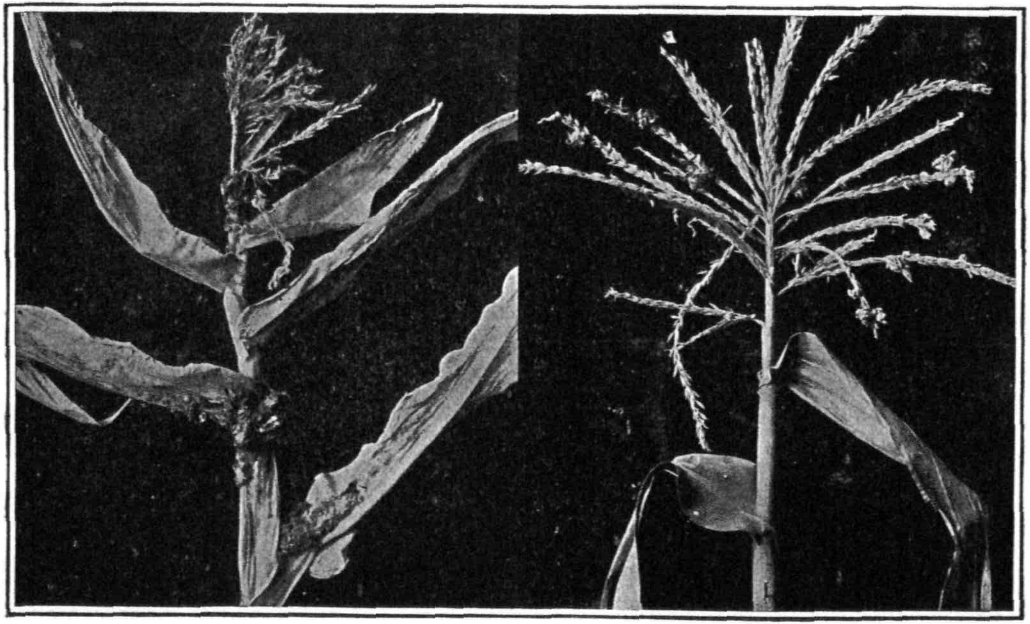


Fig 80—Smut Affecting the Tassels

botanists, led by such eminent investigators as Meyen, Leveille, Tulasne brothers, De Bary, Kuehn, Fischer von Waldheim and Brefeld, that the futility of such methods for corn became apparent. Brefeld's publication in 1895 completed our knowledge of the essential features in the life history of the fungus, and for the first time made a rational procedure possible.

The habits of the fungus are readily described. The spores, composing the black powder, are capable of growth as soon as ripe but for the most part do not grow until June, or later, of the year following. They grow best in a nutrient solution, such as the drainings from rich soil, or barnyard manure, and consequently it is the smut masses that fall to the ground in the field and are not wholly plowed under, or are distributed in yards where cattle are fed dry stalks, that chiefly furnish material for the spread of the disease.

When the spores germinate they produce a white, mold-like growth of limited extent, on which are borne minute, colorless, secondary spores. If the fungous filaments are submerged, the secondary spores are formed sparingly, but when they develop in moist air these spores are produced in the greatest profusion. It is the aerial, secondary spores that are the direct source of infection. They are carried about by air currents, and falling upon the moist surface of any part of the corn plant, not too mature, grow into the plant and cause smut pustules. Under favorable conditions it requires only twenty-four hours to produce secondary spores after the black spores find a suitable place in which to grow; and after the secondary spores strike the corn plant in growing condition but ten to fourteen days are needed for a mass of smut to form, which in a week longer will contain ripe spores. It will be seen that the reproduction of the fungus is very rapid, three weeks being ample under favorable condi-

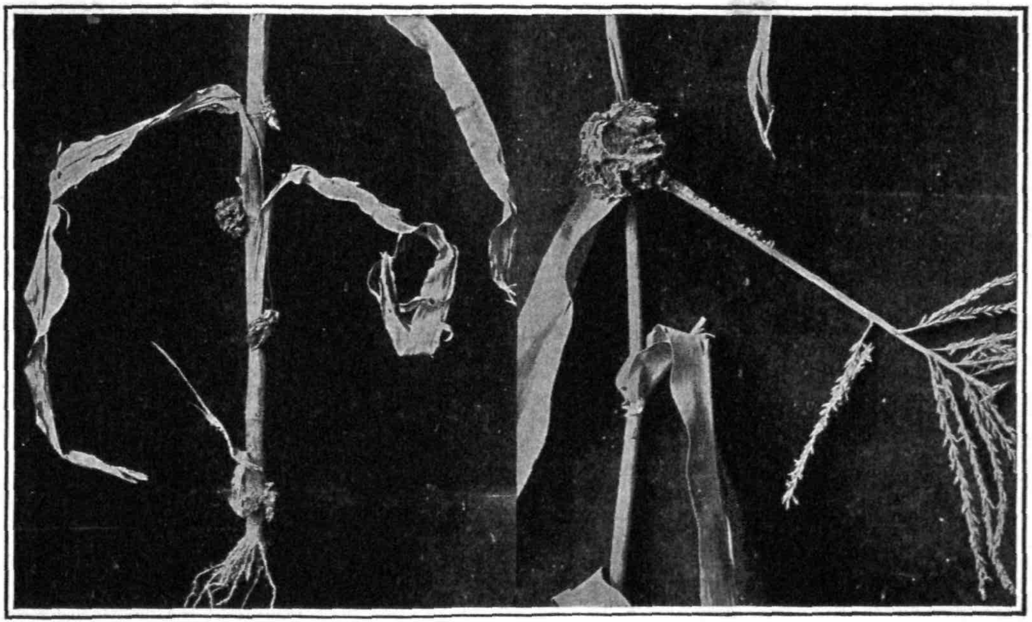


Fig 81—Smut Affecting the Joints of Stem

tions for completing the whole cycle of growth, no resting period being essential.

Observations carefully tabulated have shown that the pustules become more numerous in a field of corn as the season progresses, unquestionably due to successive infections. Early planted corn is liable to show more smut at the end of the season than late planted, simply because it has had a longer period in which to become infected. Corn planted upon extra rich or extra moist soil is more liable to infection, because the rapid growth exposes more surface of tender tissues and for a longer time. It must be remembered that the secondary spores are only able to push their germinal tubes into soft tissues. They sometimes effect an entrance into the tips of the brace roots before these enter the ground. They attack any part of the leaf when immature, and also the tassel, especially when the staminate flowers first appear. The lower part of each internode of the stem, just above the joint and inside the sheath, is particularly vulnerable throughout almost the whole season, for corn, in common with other members of the grass family, continues to grow and elongate at this point for an indefinite period. On the left (see Fig 80, showing smut affecting the tassels) the smut spores were washed in among the unfolding leaves at the summit of the stem before the tassel emerged, and the base of the leaves as well as the tassel became diseased, so that growth of the tassel was checked. On the right the infection took place after the tassel unfolded, and gained entrance through the open staminate flowers.

Not only are the tissues delicate here, but the sheaths retain moisture and provide the spores, that drop in from above or are washed down by rains or dews, good opportunity to germinate and pierce the plant. Smut often starts where the stalks are injured

by the cultivator or otherwise, thus exposing soft and moist tissues. The ear, about which the farmer is chiefly concerned, is infected through the silk, consequently, although the ear is particularly susceptible, it is only for a brief period while the silks are young and moist that it can be successfully attacked. In Fig 81 another phase is shown. On the left each joint along the lower part of the stalk bears a mass of smut, which started by spores being washed down inside the sheath, and which, as it grew, ruptured the sheath and became exposed. On the right the uppermost joint of the stalk is similarly affected, but instead of the smut mass breaking through the sheath, it has pushed the stem bearing the tassel to one side, and the sheath remains upright. Figs 80 and 81 are from photographs loaned by the Indiana experiment station.

SMUT DETRIMENTAL IN VARIOUS WAYS

The smut injures the corn crop in two ways. First, by destroying the ears of corn, causing practically a total loss, and secondly, by absorbing the juices of the plant and thus preventing full growth, especially of the ears. Statistics show that plants affected by smut, the ear remaining sound, give a yield on an average of only three-fourths the full number of bushels. The loss in yield of stover is not usually material.

Besides the actual loss to the crop there is a widespread belief that the smut does great injury when eaten by animals. This belief is not new; it is handed down from the earliest days in the history of corn growing. From the eighteenth century to the present time it has been considered dangerous for animals of any kind, or for man, to eat corn smut. It is reported to produce weakness, paralysis of the limbs, gangrene, loss of hair, staggers, abortion, and very frequently death, which is usually sudden.

Effects of Smut on Animal Life—On the other hand experimental evidence goes to show that danger from eating corn smut is very slight, if indeed, there is any at all, and that the harm which has been ascribed to it is more reasonably referred to other causes. In 1784, the distinguished French investigator, Imhof, experimented upon himself by taking a considerable quantity of the spores before breakfast every morning for a fortnight, also applying the spores to a wound on his hand, and employing them as snuff, without experiencing the slightest harm or ill effects. Other early investigators and many recent ones have tried experiments both on man and animals, and with one or two possible exceptions no injury resulted. In these trials cows, which are thought to be the chief sufferers, have been fed smut for weeks, often as much as ten pounds, or a half bushel, daily during the latter part of the time, without symptoms of injury in any particular, and with every appearance of its being an acceptable and nutritious food. Some of the cows were pregnant.

Chemical tests, and physiological studies with fluid extract of smut, however, appear to show that it contains small quantities of a narcotic substance, which taken in concentrated form may act upon the nerve centers and affect certain reflex movements, especially those of respiration. It appears possible to cause death with it, but unless that happens the effects of even large doses soon disappear and no harm follows. That it is ever possible for an animal to eat enough of the smut as found in the field to produce death seems highly improbable, unless in the possible rare case of a very susceptible individual.

A Nutritive Food—Feeding experiments have demonstrated that cattle relish the smut, and that it serves as a nutritious food. Moreover, chemical analy-

sis shows that it is richer in protein than corn, oats or clover hay, and is also high in carbohydrates. It contains about four per cent of sugar, which may help to make it palatable. It has been thought that the spores pass through the animal without impairing their power of germination, but this, like many other current views regarding corn smut, is found by trial not to be true.

A concise statement regarding present knowledge of the action of corn smut upon animals would be, that it is a highly nutritive food, quite harmless, except when eaten in excessive amounts, and then only rarely. The small quantity of a narcotic-like substance which it contains may under all ordinary circumstances be ignored.

CONTROLLING OR ERADICATING THE DISEASE

In the spread of corn smut in the field, assuming that careless husbandry has permitted smut masses to remain undestroyed, thus providing an ample source of infection, the most important factor is that of the weather. A damp atmosphere, cloudy days, and gentle winds furnish ideal conditions for the rapid spread of the smut. Under such circumstances the delicate secondary spores are wafted about without loss of vitality, and effect an entrance into the corn plant at any vulnerable point with little danger of desiccation.

Observation has shown that periods of dull, sultry weather were followed in about two weeks by outbreaks of smut. A rain storm, however, checks the spread of the smut, for it washes the spores from the air and the surface of the plants into the ground, where they come to naught. A rainy season, therefore, may be less favorable to the growth of smut than a dry season in which dewy nights are frequent.

From a knowledge of the life history of the corn smut fungus only two courses seem open at present for

controlling or stamping out the disease. One course is to protect the crop by some method of spraying so that floating spores may be killed when they come in contact with the corn plant. That it is possible to greatly diminish the amount of smut liable to occur in a field by repeated spraying with some copper compound, like bordeaux mixture, has been amply proved by trial. But it is an expensive and cumbersome method, incapable of protecting the ears from smut, because it is not wise to spray the silks when in a receptive condition, and consequently is a method never likely to come into general use.

The other course is to remove the source of infection by gathering the smut pustules before they break and scatter spores, and to thoroughly destroy them. If the smut masses are gathered from the fields of growing corn two or three times during the season, beginning in July, and the gatherings burned or plunged into boiling water, the injury from smut in the present crop and especially in subsequent ones must be greatly lessened or entirely removed. The wider the extent of country over which this method is pursued, the more permanent and complete will be the benefit. By employing boys, or other cheap labor, the method is made financially profitable.

CHAPTER XV

Cost of Growing Corn

THE selling price of every product of human labor, the production of which is open to general competition, is in the end determined by the average cost of producing that article. The truth of this rule is most clearly shown in the case of those articles of manufacture in the production of which the element of chance is most completely removed, and an exact knowledge of the cost of material and labor entering into their composition is possible. Where such absolute accuracy is possible, the producer simply sums up the cost to himself and fixes a selling price so as to allow as large a margin of profit as competition will permit. The application of this rule to the products of the farm appears difficult because of the difficulty of measuring the cost of producing any given product, but that it does apply is certain, and is illustrated by the declining course of prices of farm products that accompanies the increased use of labor saving farm machinery.

It is not possible to measure cost of production of farm products with the same accuracy as is possible with manufactured articles, but every farmer should know approximately at least what his own products cost. If he does not he is no position to market them intelligently and is assuming risks which no other business in the world carries. It is remarkable how little data of positive value bearing upon the cost of producing corn are available. Most that has appeared is in the way of loose general estimates based upon small areas grown in an experimental way, though within the past few years some careful and systematic

effort has been made to gather data upon a scale broad enough to serve as a basis for a reasonable estimate of cost of corn production.

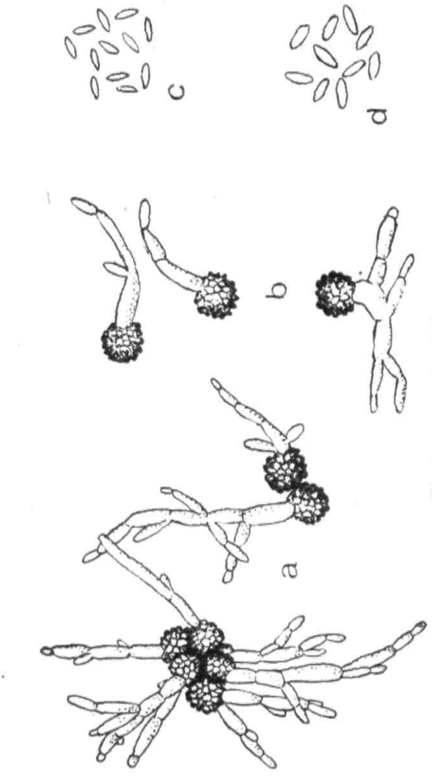


Fig 82—Corn Smut Spores

Germinating spores of corn smut, and the resulting secondary spores: *a*, two groups of smut spores showing mold-like growth after 36 hours, with secondary spores at the tips of the branches; *b*, three smut spores after having grown 18 hours; *c*, secondary spores formed in the air, which are the chief means of infection of corn plants; *d*, secondary spores formed under water, somewhat larger and plumper, but otherwise like the aerial form.

AN UNRELIABLE OFFICIAL ESTIMATE

In 1894 the United States department of agriculture published the results of an investigation as to

the cost of growing corn, based on "estimates" supplied by "over 28,000 practical farmers" in all parts of the country. The methods followed in securing the information were crude in the extreme, and the statistical treatment of the data secured very unsatisfactory leaving the results of so little value as to hardly merit analysis. In presenting the conclusions reached it may be pointed out that mere personal estimates and not exact records are the basis of the work, and that the only items of cost considered are "rent of land, manure, seed and labor." The official conclusion of this investigation, averaged for the whole country, was:

	Per acre
Rent of land	$3.03
Manure	1.86
Preparing ground	1.62
Planting	.42
Cultivating	1.80
Gathering	1.22
Housing	.50
Marketing	1.26
Total	$11.71
Cost per bushel (22.5 bushels per acre)	.52

In view of the fact that this statement does not include taxation, depreciation of horses and machinery and other items of cost, and yet shows an average cost of $2.69 per acre greater than the average value per acre of the crop for the ten years preceding, as reported by the same authority, further consideration of this "official" estimate of the cost of growing corn is unnecessary.

AN ILLINOIS INVESTIGATION

In 1898 the Illinois experiment station published a report prepared by Mr Nathan A. Weston, giving the results of an investigation undertaken to ascertain the cost of growing corn in 1896. Unfortunately, the circular issued to secure the data was so drawn as

to invite estimates rather than actual records, and was faulty to an extent that made necessary a supplementary circular at a later date. The results, therefore, are open to the objection of being based upon estimates, or at best imperfect recollection of unimportant circumstances taking place nearly a year before the asking of any questions concerning them.

The data gathered are so imperfectly presented that it is impossible to construct a table which shall

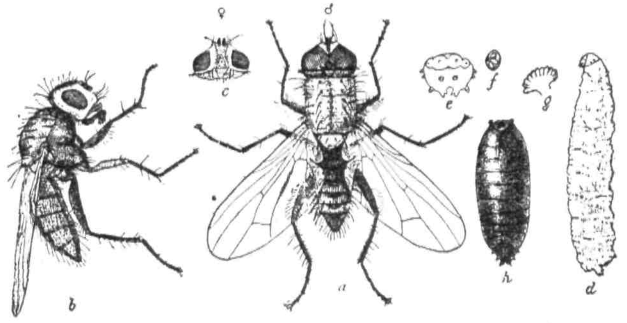


Fig 83—The Seed Corn Maggot

Phorbia fusciceps: *a*, male fly, dorsal view; *b*, female, lateral view; *c*, head of female from above; *d*, larva, from side; *e*, anal segment of larva; *f*, anal spiracles; *g*, thoracic spiracles; *h*, puparium—all much enlarged (after Chittenden).

show in detail the cost of the various items necessary to a showing of the cost of growing corn. The final conclusion is that the "cost per bushel through husking" averaged 16.1 cents, qualified by the statement: "If we omit rent, the cost per bushel through husking would according to this inquiry be about eight cents." In view of the fact that this does not include any allowance for depreciation of horses or machinery, team maintenance during their period of idleness, fertilization, and other items of cost always present, even the final conclusion cannot be accepted as having any very positive value.

A CAREFUL WISCONSIN INVESTIGATION

In his report of 1898, Mr Halford Erickson, commissioner of statistics for Wisconsin, presents a valuable contribution of data upon the question of cost of producing staple crops. It is based upon exact records kept by a large number of representative farm-

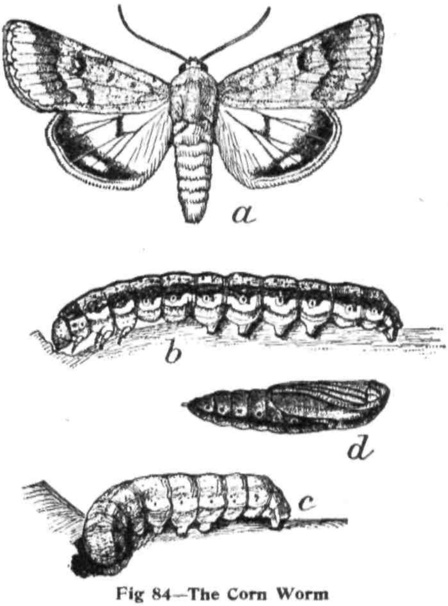


Fig 84—The Corn Worm

Heliothis armiger : *a*, adult moth; *b*, dark full-grown larva; *c*, light-colored full-grown larva; *d*, pupa—natural size (after Howard)

ers, the method followed in securing the data being exactly the same as that pursued in the *American Agriculturist* and *Orange Judd Farmer* investigation, which will be presented in detail later. This estimate includes as part of cost production interest on perma-

nently invested capital, the propriety of including which is doubtful. The averages of the Wisconsin investigation are as follows:

	Per acre
Plowing	$0.535
Fertilizing	.690
Harrowing, etc	.230
Planting	.143
Seed	.080
Cultivation	.677
Cutting	.930
Husking	1.340
Shelling	.550
Marketing	.560
Taxation	.256
Team maintenance	.867
Depreciation of machinery	.429
Depreciation of horses	.125
Other expenses	.500
Total	$7.912
Less value of fodder	3.000
Total cost per acre	$4.912
Cost per bushel (42 bushels per acre)	.117

Adding the allowance for interest on permanent investment the statement becomes:

	Per acre
Annual investment (details above)	$4.912
Interest on machinery investment	.257
Interest on value of horses	.075
Interest on annual investment	.475
Interest on value of land	2.640
Total	$8.359
Per bushel	.199

INDIVIDUAL ESTIMATES OF COST

There are many methodical farmers who realize the importance of knowing what it costs them to produce their crops, and such men possess data which answer the question of cost of growing so far as their own well-managed farms are concerned. The

Hiram Sibley estate at Sibley, Illinois, a notable example of large and well-managed farming operations, has accurate records of cost of producing its crops. The manager, Mr F. A. Warner, has submitted the following showing of the cost of growing a crop of sixty acres of corn upon that estate:

COST OF PRODUCING CORN ON SIBLEY ESTATE, SIBLEY, ILLINOIS

Fall plowing, 45 acres at $1 per acre	$45.00
Spring plowing, 15 acres at $1 per acre	15.00
Breaking stalks on 15 acres	3.00
Disking on fall plowing, 45 acres	18.00
Harrowing	10.50
Seed corn, 9 bushels at 75 cents	6.75
Planting	12.00
Harrowing after planting	10.50
Cultivating three times	78.00
Thinning and weeding	10.00
Husking, at 2 1-2 cents per bushel	62.25
Shelling and hauling, at 2 1-2 cents per bushel	62.25
Total cost	$333.25
Taxes	20.00
Insurance and repairs	10.00
	$363.25
Cost per bushel (41.5 bushels per acre)	.146

This cost is figured on the basis of the actual accomplishment per day's labor, labor being charged at the rate of $2.50 per day for man and team and 50 cents per day for extra horses where used. This wage includes board and keep of man and team.

The crop was 2490 bushels, making the average yield per acre 41.5 bushels, and the cost per bushel 14.6 cents. The land was valued at $80 per acre, or $4000 for the field, and if interest be allowed upon this investment at the rate of 6 per cent, it raises the cost

of the crop to $651.25 and the cost per bushel to 26.2 cents.

Record on a Nebraska Farm—One of the most valuable collections of data relative to cost of production in a given locality of which the writer has knowledge, is found in the annual records kept by Mr R. M. Allen, manager of the Standard Cattle Company, for the farms of the home feeding station at

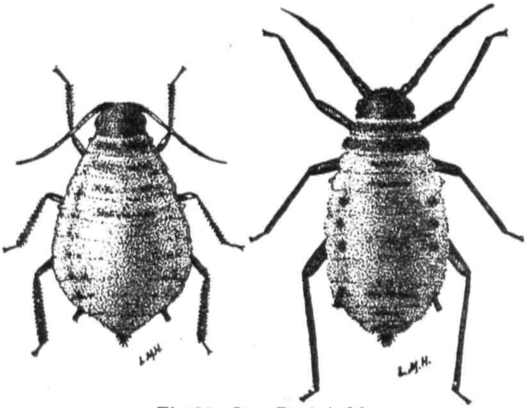


Fig 85—Corn Root Aphis
Male and oviparous female enlarged (after Forbes)

Ames, Nebraska. These crops have been grown on different kinds of soil, from sandy to very heavy, sticky, black gumbo in the Platte river valley. The record as presented below covers a ten-year period, thus including both good and bad seasons. Farming on this place is carried on as an exact business and the figures presented are exact records as drawn from the books of the company. Under the head of operating expenses is included manuring of a portion of the acreage each year and the cost of producing, harvesting and cribbing the crop. From this gross cost is

deducted the value of the stover, according to the character of the season, ranging from $1.46 per ton in 1896, a season of very cheap hay, to $5 per ton in 1894, the year of great drouth and deficient hay crop. The figures do not include any allowance for either rent of land or interest on the permanent investment It is interesting to note the close relation between the average cost per bushel for the ten years, and the average cost of 12.9 cents presented in the *American Agriculturist* investigation which is reviewed at length later.

COST OF GROWING CORN ON STANDARD CATTLE COMPANY FARM, AMES, NEBRASKA

Year	Acr's	Bushels	Bu per acre	Oper't'g expenses	Val of stover	Net cost	Cost per a	Cost per bu
1891	1,825	42.000	23.0	$8,134.20	....	$8,134.20	$4.46	$0.194
1892	1,825	51,344	28.0	8,479.97	....	8,479.97	4.67	.165
1893	1,325	60.028	45.3	8,956.30	1,312.50	7,653.80	5.78	.127
1894	1,792	41,001	22.8	12,930.33	7,165.00	5,765.33	3.22	.141
1895	1,875	76,154	40.6	17,217.48	4,296.00	12,921.48	6 89	.170
1896	2,462	169,031	68 6	27,593.40	9,320.70	18,272.70	7.42	.108
1897	2.717	111,932	41.1	22,346.00	13,446 00	8,900.01	3.28	.079
1898	3,431	108,090	31.5	28.178 49	10,900.00	17,278.49	5.04	.160
1899	1,644	60,837	35.9	15,275.80	5,862.00	9,413.80	5.73	.155
1900	2,735	124,995	35.0	25,451.00	10,000 00	15,451.00	5.65	.124
Tot'l	21,631	845,412				$112,270.78		
Avg			39.1				$5.19	$0.133

AMERICAN AGRICULTURIST AND ORANGE JUDD FARMER ESTIMATE OF COST

In 1897 these journals published a series of articles upon the cost of growing corn based upon data furnished by growers who had kept detailed records of all items of cost connected with their crop in 1896. Up to that time, no systematic and scientific effort to determine on any large scale the cost of production of any staple farm crop had ever been made, and most erroneous estimates of this cost were currently accepted. The method adopted to secure the necessary

data was simple and effective. A large number of corn growers were induced to keep an actual day to day record, upon a specially prepared blank, showing the exact amount of labor and other expense bestowed upon a certain definite area, and when the season was over these records were consolidated and the results averaged.

This investigation covered but eight states, and it was determined to prosecute a second investigation which should include systematic results typical of the conditions under which corn is grown in all sections of the country. The original plan of securing actual day to day records was adhered to, the circulars being so arranged as to secure the exact record of all expenses attached to the growing of the crop from fertilization and preparation of the soil, through the whole season's work, in the order in which performed up to the cribbing of the crop. These circulars were in the hands of the growers before the first plow entered the ground and continued in their possession until the crop was gathered.

In tabulating these individual records only those absolutely complete and perfect were used, these covering 4051 acres, located in 156 counties of 21 states. In this area was included corn grown under various methods practiced in different parts of the country, so that the averages presented do not represent the cost under any particular method, but an average of the various methods.

What Is Cost—In analyzing the data secured by this investigation, the term "cost of production" is used in its popular significance, as representing the actual outlay or the amount of capital actually used up and which must be wholly replaced before any profit upon the fixed or permanently invested capital can be secured. In the tabulations to be presented this covers

taxation, labor and labor maintenance, fertilizing material, seed, team maintenance and depreciation of machinery and horses. Land, horses and machinery are treated as permanent capital and an allowance of interest on this permanent investment is not considered as part of the cost of production, but the net profit on the crop after all the circulating capital which has been used up has been replaced is taken as the profit of production and therefore is the interest returned on the permanent investment.

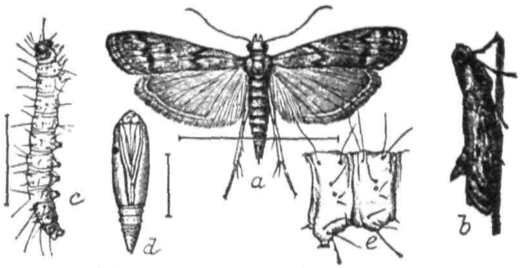


Fig 86—Mediterranean Flour Moth

Ephestia kuehniella: *a*, moth; *b*, same from side, resting; *c*, larva; *d*, pupa—enlarged; *e*, abdominal joint of larva—more enlarged (after Chittenden)

Labor and Wages—The great bulk of the corn crop is produced by the labor of the owner of the crop. Some hiring is done in stress of work, but this usually supplements the labor of the owner. In figuring labor cost the rate of wages paid where hiring is done by the day is used, the assumption being that the owner is entitled to charge his labor at the highest local market price. By common custom in every community, there is a wage rate for labor with board furnished and another where the laborer boards himself. The difference between the two rates represents the value or cost of maintenance as determined by experience and custom. In this investigation cost of wages and

cost of labor maintenance are figured together by making the wage basis the rate of wages per day without board. Having the number of days' labor given to each operation pursued in the growing of the corn crop and the average rate of wages per day without board, the cost of labor and labor maintenance becomes a simple matter. The average wages per day without board ranged from 60 cents in Virginia to $1.50 in Maine, averaging for the 21 states $1.10.

Teams and Maintenance—The meaning of team is not the same in all districts or in all operations. It may be two, three, or more horses. To bring the various customs to a common basis the number of horses used in any operation is reduced to a common standard of teams of two horses. As an illustration, if four horses were used to plow in a given crop, it enters into the calculation as two teams. The horse power used in making the crop may be regarded from two standpoints. Wage allowance may be made for their services on the basis of the rate usually paid where horses are hired. The second way of considering horse power is regarding the necessary complement of horses on the farm as part of the permanently invested capital. Beyond question this is the proper method. On this basis annual cost of team maintenance and an allowance for depreciation is the proper charge against the crop. This charge may be made in two ways. The first is to ascertain the average cost per day of team maintenance, charging the corn crop with maintenance only for those days in which the team is actually engaged in producing the crop. This plan would be followed upon the assumption that the horses of the farm are constantly engaged in some form of farm work, and that the cost of their keep and care each day should be charged to the work then engaged upon. The objection is that horses are not employed equally

day by day and their maintenance in their days of idleness must be charged to some portion of the farm work.

The other plan of charging for horse power, which is considered the most equitable, is to divide the annual cost of maintenance of all horses required in the ordinary work of the farm by the total acres of cultivated land in the farm. The whole cultivated area shares in their work and should share in the cost of keeping

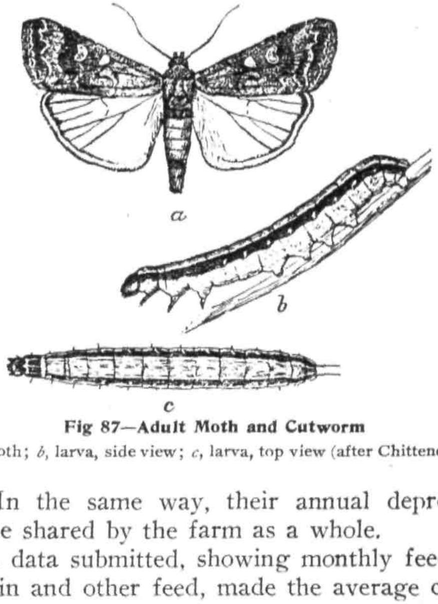


Fig 87—Adult Moth and Cutworm

a, moth; *b*, larva, side view; *c*, larva, top view (after Chittenden)

them. In the same way, their annual depreciation should be shared by the farm as a whole.

The data submitted, showing monthly feeding of hay, grain and other feed, made the average cost per month of maintaining a team of two horses $8.21, with a range from $12.91 in Massachusetts to $5.98 in Nebraska.

Horse Power and Machinery—The horse on the farm is what steam is to the manufacturer: power. Horses are therefore properly part of the permanently

invested capital of the farm. Treated in this way the charge for horse power in crop production is the annual cost of their maintenance and the annual depreciation of their value. The farms included in the schedule of this investigation aggregated 26,522 acres, the number of horses required in conducting the farming operations was 781, their total value being $39,525, an average of $50.60 per head. The value per farm acre of the horses necessary to farming operations was $1.49. The monthly cost of team maintenance, as shown above, was $8.21, making the annual cost of maintenance of the necessary complement of horses for the farm work $38,472, or a cost per farm acre of $1.45.

Taxation—The rate of taxation per acre of the corn land is ascertained by securing the total taxation on the land, buildings, stock and implements, the fixed capital, and apportioning the taxes equitably between this total farm value and the value of the corn land alone. The average rate of taxation is 28.3 cents per acre, ranging from 3 cents per acre in Virginia to 79 cents in Massachusetts. This seems a wide range, but when the value per acre of the land is considered the taxation is more equitable, being .6 of 1 per cent of the value in Virginia and 1.3 per cent in Massachusetts.

Rent, Interest and Implements—The average cash rental per acre of land similar to that reported upon was returned at $3.05, ranging from an average of $1 in Virginia to $5.25 in Pennsylvania. The average value per acre of the corn land was returned at $47.71, and on this valuation the cash rental equals 6.4 per cent. The average rate of interest at which loans could be secured was reported at 7.1 per cent, ranging from 5 per cent in New England to 10 per cent in Texas.

The quality and effectiveness of farm implements varies greatly and the amount of fixed capital invested in such machinery varies equally. From the

data submitted it appears that the average investment required to furnish implements for a 40-acre corn field was $83.59, or $2.09 per acre, ranging from 87

Fig 88—Work of the Larger Cornstalk Borer

a, general appearance of stalk infested by the early generation of borers; *b*, same, cut open to show pupa and larva burrow (after Howard)

cents per acre in Virginia to $2.62 in Iowa. The average effective life of such implements was a fraction over 10 years, thus fixing the allowance for depreciation of implements at 20.9 cents per acre. This allow-

ance includes repairs necessary during the life of the implements.

Labor and Its Statistical Treatment—The amount and character of labor required to make a corn crop necessarily varies according to the culture methods followed. In the 4051 acres included in this investigation various culture methods were used. As an average must include all methods, the total amount of labor required to perform a certain operation is distributed over the total area, although actually the labor was performed on only a part of the acreage. For example, it was necessary to remove stalks on only 1673 acres, but the labor cost of this operation is necessarily divided among the whole 4051 acres. So far as possible, however, the labor cost of the different operations is grouped into certain fundamental divisions of culture according to the result aimed at by the operation in question. The term "labor cost" as used in this analysis includes wages and labor maintenance, but does not include cost of team maintenance, that being included later in the tabulation as a separate item.

Removing Stalks—When corn is grown two years in succession, the first work of preparation is the removal of old stalks. Cutting up and carrying off was practiced on 784 acres, requiring 91½ days of labor and 76 days of team service. The actual accomplishment was 8.6 acres per day of labor. Breaking, raking and burning was practiced on 889 acres, requiring 92 days of labor and 79¾ days of team service, the average accomplishment being 2.4 acres per day's labor.

Plowing—Of the 4051 acres, 3491 acres were plowed, the remaining 560 acres being listed in. To plow 725 acres in the fall required 293 days of labor and 382 days of team service, or an accomplishment of 2.47 acres per day's labor. The discrepancy between days of labor and days of team work is of course

due to the fact that more than two horses were frequently used to the plow, and in all such cases team work is stated in the equivalent of two horses. The spring plowing of 2766 acres required 1154¾ days of labor and 1479 days of team service, an accomplishment of 2.4 acres per day's labor.

Harrowing—The amount of work done in the way of harrowing, disking, rolling, dragging and

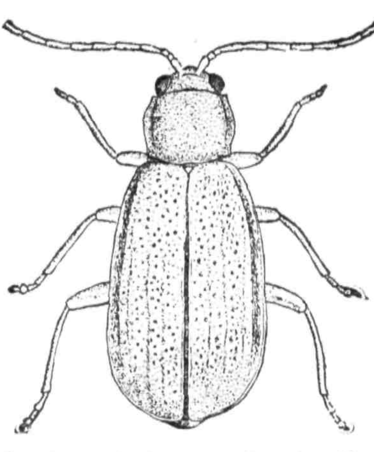


Fig 89—Beetle of Northern Corn Root Worm
Enlarged ten diameters (after Forbes)

otherwise preparing the seedbed varies greatly in local practice. Instances appear in the schedule where the field was worked seven times, while in other cases only one working was given. Of the 4051 acres, harrowing or other similar preparation was practiced on 3280. As only 560 acres were listed, this leaves 211 acres on which planting followed plowing with no effort to prepare a seedbed. It required 496¾ days of labor

and 668¼ days of team service to accomplish the harrowing, or an average of 6.6 acres per day's labor.

Listing—This method of planting is little practiced except in Kansas and Nebraska. Under the proper soil and climate conditions it is a desirable method, and so far as the amount of labor required is concerned it is far cheaper than the usual practice. In this investigation 560 acres were listed, requiring 92½ days of labor and 119¼ days of team service, the accomplishment per day's labor being 6.1 acres.

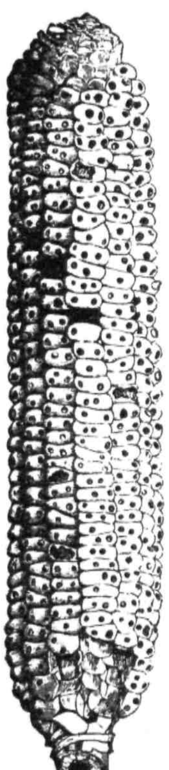


Fig 90—Ear of Corn Riddled by the Grain Moth

(After Riley)

Fertilization—The percentage of the total corn acreage which in any year is fertilized by the direct application of fertilizing material is so small as to hardly merit consideration. Where this is done at all it is usually thus treated once in a series of years, so that the full cost of such treatment cannot properly be charged to the single crop following. The usual method of maintaining fertility is by devoting the land occasionally to some renovating crop, like clover, and when this is done it is obvious that some allowance must be made for the less valuable product of the land in that year, but what that allowance should be cannot be determined with accuracy.

In this investigation no allowance has been made

for fertility directly applied, and in such cases the full cost has been charged to the crop in question. This course undoubtedly makes the charge allowed for fertilization higher than it actually averages, but no other course seems open without the introduction of personal estimate into a calculation which is intended to be an actual record. In the schedules fertilization was reported on some parts of 1639 acres, requiring 635¼ days of labor and 483¼ days of team service. There

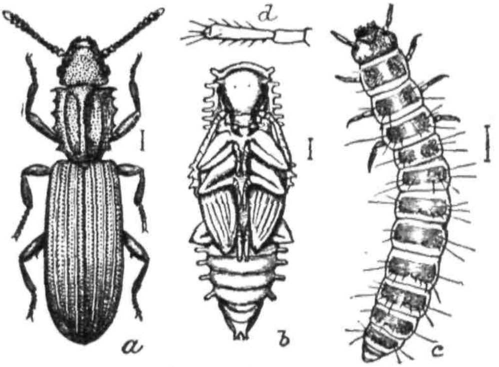


Fig 91—Saw-toothed Grain Beetle

Silvanus surinamensis: *a*, adult beetle; *b*, pupa; *c*, larva—all enlarged; *d*, antenna of larva—still more enlarged (after Chittenden)

were used 9100 pounds of commercial fertilizer, costing $86.85, and 5977 loads of homemade material, valued at $2413.95.

Planting—Planting methods included the whole range from hand dropping and hoe covering to the use of hand planters, and up through machines of varying efficiency to the best modern horse planters. As a result the efficiency of a day's labor varies widely, from .71 of an acre in New Hampshire to 12.44 acres in Nebraska. The acreage regularly planted was 3491

acres, requiring 442¼ days of labor and 375¾ days of team service, an average accomplishment of 7.89 acres per day's labor.

Cultivation—Cost of cultivation differs more than any other operation, owing to differences in implements used, and to differing degrees of care and labor given the crop. The whole area, 4051 acres, was cultivated twice; 3991 acres were cultivated three times; 2515 acres received a fourth cultivation, while 442 acres were given additional cultivation. To perform the total amount of cultivation given to the crop of the record required 2296½ days of labor and 2297½ days of team service. The average performance per day's labor was 1.76 acres, this of course representing the total cultivation given to this breadth during the whole season. A day's labor sufficed to cultivate about 6.6 acres a single time.

Gathering and Cribbing—Two methods are followed, first, cutting up and shocking and husking from the shock; second, husking from the standing stalk, the stalks remaining in the field to be pastured down. In this investigation 2976 acres were husked standing, requiring 2438¼ days of labor and 2264 days of team service, the accomplishment being 1.22 acres per day's labor, this including cribbing as well as husking. Of the crop cut up, 659 acres was done by hand, requiring 595¾ days of labor, or 1.11 acres per day. Machines were used in cutting 215 acres, requiring 74 days of labor and 48¾ days of team service, the accomplishment being 2.91 acres per day's labor. The balance of the acres of record was harvested by contract and is therefore not included in the calculation of the efficiency of labor per day.

Husking from the shock was practiced on 651 acres, excluding 212 acres by contract, requiring 1223¾ days of labor and 382½ days of team service,

or an accomplishment in husking and cribbing of .53 acre per day's labor.

Fodder—The value of fodder as a by-product must be taken from the gross cost of growing the corn crop. Where the crop is cut and shocked, the value

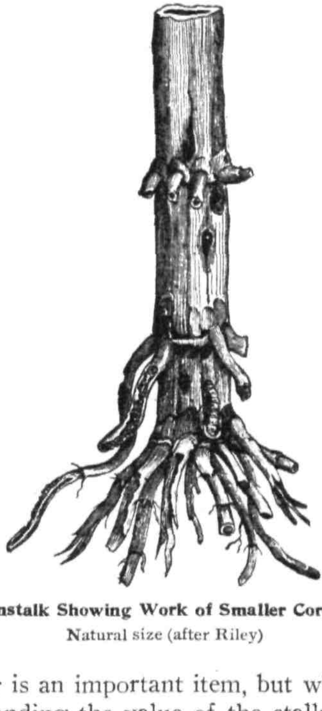


Fig 92—Cornstalk Showing Work of Smaller Cornstalk Borer
Natural size (after Riley)

of the fodder is an important item, but where the crop is husked standing the value of the stalks for pasturage is slight. Fodder was shocked on 945 acres and this product was returned as worth $2174.70 in the field, or an average value per acre of $2.30 where the fodder is cut. On the 3106 acres where the crop was husked standing, the selling value of the pasturage

privilege was estimated by the owners at $990.60, or an average of 32 cents per acre. The aggregate valuation of fodder production by both methods was $3165.30, or an average per acre of 78.1 cents.

Production—The total production of corn was 158,815 bushels, or 39.2 bushels per acre.

With the preceding analysis of the methods followed in this investigation, the following table is presented as a fair showing of the cost of producing the corn crop on the 4051 acres included in these schedules:

ORANGE JUDD FARMER CONCLUSION AS TO COST OF GROWING CORN

	Acres so treated	Total cost	Actual cost per acre	Av cost per a whole area
Cutting stalks	784	$108.60	$0.139	$0.054
Breaking stalks	889	110.13	.124	
Plowing	3,491	1,723.48	4.94	.425
Harrowing	3,280	584.86	.178	.144
Listing	560	110.46	.197	.027
Fertilization	1,639	3,275.89	1.999	.809
Planting	3,491	519.84	.149	.155
Replanting	1,086	108.69	.100	
Seed	4,051	332.35	.082	.082
Cultivation	4,051	2,752.44	.679	.679
Husked standing	3,106	3,120.76	1.005	1.372
Cut by hand	730	725.45	.994	
Cut by machinery	215	95.55	.444	
Husking from shock	867	1,616.95	1.865	
Taxation	4,051	1,147.78	.283	.283
Team maintenance				1.450
Depreciation of machinery				.209
Depreciation of horses				.149
Total annual investment				$5.838
Less value of fodder				.781
Actual cost per acre				$5.057
Cost per bushel (39.2 bushels per acre)				.129

Cost with Allowance for Interest on Investment—It has been previously pointed out that in determining cost of production no allowance is made for interest on capital permanently invested. The difference be-

tween the annual investment and the value of the crop produced represents the profit of production or the percentage of gain on the permanent investment. For the benefit, however, of those who desire to include interest or rent, the following table is presented, showing the proper allowance for interest on capital invested, at the rate of 6 per cent:

COST WITH INTEREST INCLUDED

	Per acre
Annual investment (details above)	$5.057
Interest on machinery investment	.125
Interest on the value of horses	.089
Interest on annual investment	.303
Interest on value of land	2.862
Total	$8.436
Per bushel	.215

CONCLUSION

The tabulations which have preceded have included every item of cost of production, except an allowance for annual repairs of buildings, fences and farm roads, insurance and superintendence. The allowance for these items must necessarily be a matter of opinion only. Leaving them out of the question, the data presented show that the cost of producing a bushel of corn of the crop under record may be fairly placed at 12.9 cents, and if sold from the crib at 21.5 cents it would net the producer 6 per cent on his permanently invested capital.

CHAPTER XVI

New Uses of Corn

Corn will yet be the spinal column of the nation's agriculture.—James G. Blaine.

CORN is the foundation of American agriculture, but the full possibility of the crop is not yet appreciated. It is only within a decade or so that it has been regarded as other than a rude, primitive food for man and the feed par excellence for meat producing animals. During the past few years, however, attention has been directed to the economic possibilities of the corn plant, and scientific study and inventive genius have combined to open new lines of commercial importance in connection with our great cereal.

The fact is only imperfectly realized that corn has forms of commercial value other than as cattle food, human food in the shape of meal, or for distillation of spirits. Yet at the Paris Exposition of 1900 in the American section there was exhibited a museum case containing one hundred and eight separate commercial products manufactured from corn. In this long list there was no direct duplication, each article having a different commercial use, though naturally there were some items that were only differentiations of the same product. But as each was intended for a different use the list practically represented fully one hundred commercial products. Such a list is a revelation of the rapidly growing importance of corn as the raw product base of manufacturing industry.

Three Classes of Products—Roughly speaking the commercial products of corn may be divided into those

produced by mechanical or milling methods, those by chemical process and those made from the stalk or plant. Improvement in milling machinery has been very marked in the last few years, and the result is a large increase in the number of forms in which corn is made available for human food. Under old milling methods corn could only be ground into a coarse meal, and this was the only form in which it entered into the dietary of the people. This old process meal was made by grinding the whole grain, and it therefore contained the large percentage of oil which is in the chit or heart. This excess of oil made it difficult to preserve the meal fresh and sweet, its keeping quality being low, and it was not a safe product for commercial purposes.

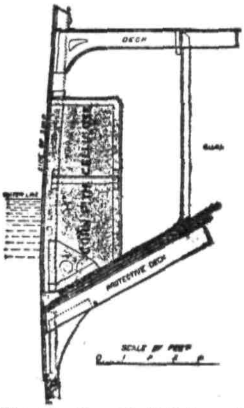


Fig 93—Use of Cellulose in Warships

The accompanying sketch illustrates the use of cellulose, a product of corn pith, in protecting warships from shot and shell. If a shell from the enemy pierces the side of the ship below the water line, and passes through three feet of corn pith cellulose into the ship, the cellulose will swell up so quickly that no water will get in. A number of United States warships are thus protected.

The improvement in corn milling is by the adoption of the roller reduction process similar to that used in wheat milling, but requiring much greater power, and by this process a flour is produced quite as impalpable as the best grades of wheat flour. Through the use of very ingenious machinery the chit, or germ, is mechanically removed from each grain of corn before it passes into the rolls, by this means removing all but a trace of oil from the meal or flour. The product by this process loses some of the distinctive corn flavor,

but the loss is more than offset by the gain in keeping quality, and corn flour can now be used or shipped under the same conditions as wheat flour. Corn being without gluten in its composition this flour must be used in connection with strong wheat flour, and when properly blended as much as thirty per cent of the cheaper product may be used, thus cheapening the cost of bread and furnishing a palatable and nutritious product.

In the process of gradual reduction there is a demand for the product at different stages of manufacture. When the grain has passed through the first process the coarsely broken grains are sold as samp or hominy, for which there is a large and growing market. An export trade of very considerable proportions has grown up in this product. When it has been further passed through the rolls and broken finer it finds its way to the table as a breakfast food under various names of hominy, pearl hominy, grits, etc. With each reduction there is cracked or dusted out a fine grainless powder, almost pure starch, that finds a market for special purposes in the confectionery and fine baking trade.

Glucose—An industry which has become one of enormous proportions is the manufacture of glucose and kindred products. This belongs to the division of products the result of chemical process. Probably more than sixty million bushels per annum are now consumed by the glucose factories, and the industry is growing rapidly. Thirty or more separate commercial products, for which a permanent market has been established, are now made. Glucose is made in various grades of density, each for a specific purpose, the largest use being in the manufacture of table syrups and of confectionery. Other products are dextrin and gums for sizing cloth and especially as a medium for

carrying colors in cloth printing. Various grades of starches, from edible to laundry, are also produced. These products may be regarded as the principal or

Fig 94—Ear of Smutted Corn

This ear is affected with smut only at the tip where it was imperfectly covered by the husks. From photograph loaned by the Indiana experiment station.

original products of the glucose works, but there are a long line of by-products of large commercial and

economic value. The principal of these are corn oil and oil cake, oil cake meal; various grades of cattle feed in the shape of gluten feed, bran, etc.

Cornstalks in Mechanic Arts—Another line of products in which exploitation is just beginning is secured by a complete utilization of cornstalks. The full economic possibility of the stalk is not yet understood, but practical experience to some extent and laboratory experiments still further demonstrate that enormous wealth-producing possibilities are wasted in the failure to utilize cornstalks. Scientific tests have demonstrated that there is as much economic value in the stalks as in the crop of grain they bear, but up to this time the mechanical difficulties in the economical handling of the stalks have not been fully overcome. Good progress, however, has been made in that direction, and it will only be a question of time until inventive genius will solve the problem.

The most important product which is now a commercial success is the manufacture of cellulose from the pith of the cornstalk. This product has numerous chemical uses, but the important mechanical want which it fills is its availability for use as a packing between the inner and outer shell of warships. Upon contact with water it swells enormously and thus automatically closes water tight any aperture made by a shell or projectile piercing the ship's armor. The use of a backing of this kind is now specified in the construction of war vessels by nearly all naval nations.

After the pith is extracted the remainder, chive or outer casing of the stalk, leaves and tassels, are ground into a coarse meal which careful experiments have shown to have a nutritive value for stock feeding little different from clover or timothy hay. In laboratory experiments numerous other products have been made, alcohol, paper, smokeless powder, etc, and there

is every reason to believe that the experiments of to-day will be the demonstrated facts of to-morrow.

The economic possibilities of the corn crop are only beginning to be understood, and it is only a question of time until it shall become the most valuable and widely used of the world's cereals.

CHAPTER XVII

Specialties in Corn Culture

SWEET corn is a species group of field corn known botanically as *Zea saccharata,* and is characterized by horny, more or less wrinkled, crinkled or shriveled kernels, having a semi-transparent or translucent appearance. It is a native of America, although the wild form has never been discovered. It was first known about 1779, but it was not until 1850 or thereabouts that it was cultivated to any extent. At that time but two varieties were known. It is pre-eminently a garden vegetable, although the large growing kinds are used for forage and feeding purposes. The kernels are generally used green, also cut off the cob and dried to some extent, but dried corn is being supplanted largely by canned corn, the packing of which has grown to enormous proportions in the past few years. Although several million cases containing two dozen Number 2 cans each are packed each year, it is almost entirely consumed within the United States and Canada; the foreign market for canned corn is capable of large development. Each standard can weighs twenty-six ounces, including tin.

The production of corn for canneries is very important business in certain sections, notably in New York, Maine, Illinois, Iowa, Ohio and some other states. It is grown by farmers as a field crop, who sell the ears to the factory and use the stalks for feeding purposes. As the ears are picked in their roasting stage, the stalk has opportunity to develop and

contains more nourishment than where the ear is allowed to ripen. It is so rich in sugar that it spoils easily, if not kept and stored under the best conditions, and is somewhat harder to handle because of this than field corn.

A constantly increasing area is devoted to sweet corn intended to be sold green in the husk for immediate consumption in towns and cities. Usually this is quite profitable, especially if the crop gets into market early. The demand for out-of-season specialties at high prices has led to the growing of sweet corn in greenhouses, in a small way, at a profit, and its culture under cheesecloth sheds has also been suggested.

BEST CONDITIONS FOR SWEET CORN

Although sweet corn will grow on a large variety of soils, the best is a warm, sandy loam which retains moisture. Where it is raised for market, it is essential to have a warm, quick soil that will bring it in early, for the first corn fetches top prices, and when the main crop comes in the price falls rapidly. A difference of three or four days in time of maturity will often make a difference of several cents per dozen ears in the market price.

In addition to a warm, quick soil, some quick-acting fertilizers are desirable, especially in sections remote from the central west, with its natural fertility. The preparation of the soil should begin by rather deep plowing and the turning under or working in of a liberal application of stable manure. Use also two hundred or three hundred pounds of quick-acting fertilizer per acre, which should be put in the drill with the corn to give it a rapid start. When sweet corn is grown by market gardeners within hauling distance of large cities, sometimes as much as five hundred to one

thousand pounds per acre of commercial fertilizer is used. As the roots of corn do not go deep in search of plant food and moisture, the plant will not stand long and extended periods of drouth, therefore the preparation and cultivation of the soil should be such as to conserve all moisture possible and to keep the plant growing rapidly.

Sweet corn is a tender plant and will not stand much cold weather or any frost, therefore it should not be planted until danger of frost is over and the ground has become warm. If planted in cold soil, the seed will often rot before sprouting and replanting is necessary. The ground is commonly marked into rows three to four feet apart and the corn planted in hills from two and one-half to three feet in the row, or in drills so that one stalk will stand in each foot. For the family garden, it is desirable to get the first crop as early as possible, therefore an extra early planting may be risked. Not only should an extra early variety be selected, but the seed may be artificially sprouted. To do this, put sand one inch deep in the bottom of a large pan or shallow box. Spread a cloth over this and the corn thinly on the cloth. Cover with another cloth and then a layer of sand one-half inch deep. Sprinkle with water and keep warm by the stove or in a hotbed or greenhouse. The corn will all sprout in about five days. By this method of sprouting the seed is tested, the danger of rotting is reduced to a minimum and the harvest time is also hastened several days.

After sprouting, the corn must be at once planted in the open ground. Another way is to plant five or six kernels in a five-inch pot and allow three plants to grow. If carefully done, the corn can be transplanted when six inches high and several days in maturity gained thereby. Even though the first planting should

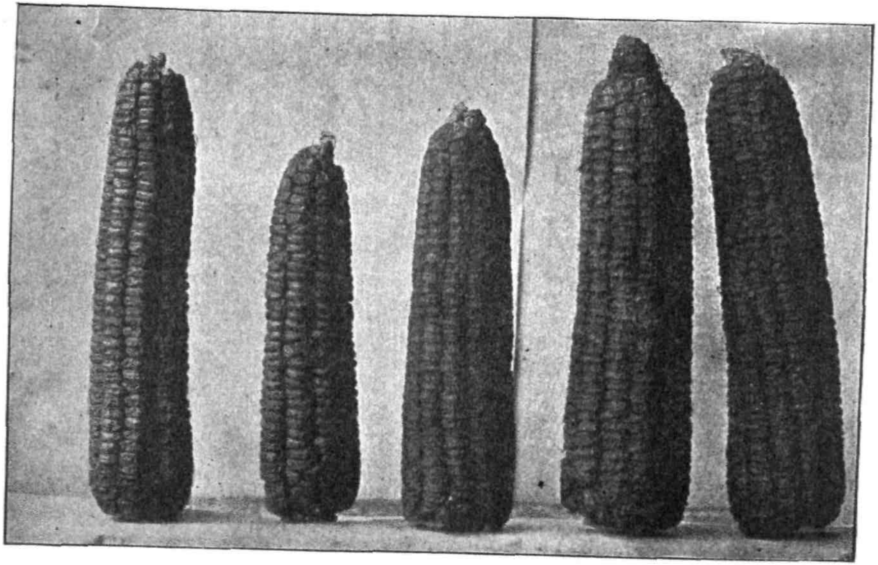


Fig 95—Specimen Ears of Early Sweet or Sugar Corn

Beginning at extreme left, the varieties, in order, are named as follows: Cory, Early Minnesota, Early Crosby, Perry Hybrid, Moore Concord

be killed by a late frost, but little is lost thereby in the family garden. The main crop should not be planted until all danger of frost is over, which will vary in different latitudes.

For the family garden, several varieties should be planted, beginning with the extra early and choosing a selection which will mature one after the other, and in this way keep the table supplied from late July until well into October. After the main planting additional plantings should be made at intervals of two or three weeks up to the first of July. If the first sharp frost in the fall catches a patch of sweet corn with the ears in roasting condition, all change seems to be arrested. Although the leaves turn white and are of little use for cattle feed, the ears seem to undergo little change and will remain in good eating condition for two or three weeks and can be picked from day to day as wanted, but for canning they are practically useless.

CULTIVATION AND HARVEST

The cultivation should be frequent and thorough. A few days after corn is planted, run over the ground with a weeder and follow this up at intervals of four days to a week until the corn is six to eight inches high. The use of the weeder when corn is of a fair hight will tend to prevent too rank growth of stalk and to induce greater fruitfulness and the production of larger, better ears. After the weeder, use the cultivator, letting it run at a fair depth to induce as deep rooting as possible. A plow should never be used which will cut off the roots nor should the last cultivations be deep enough to injure them.

Sweet corn is commonly harvested when the ears have reached what is known as the roasting stage. A good way to determine whether garden corn is in the

proper stage for use is to split the husk with the two thumbs about midway of the ear. An opening about an inch long can be made through which the ear can be examined, and if immature the leaves can be closed again by gentle pressure. This method can be used without noticeable injury to the ear. If a few husks are stripped down, as commonly done, the corn quickly spoils when exposed in this way. This method is not practicable for the market gardener or when picking for canneries. A little experience will teach the picker to tell by handling the ear when the kernels are plump and full, so he may know which to pick and which not to.

After picking, sweet corn, like peas, changes quickly, and loses its sweetness if allowed to heat. To obtain these two vegetables in perfection it is absolutely necessary that they be prepared and eaten as soon after harvesting as possible and before the sugar has had time to change to starch. This latter process takes place quickly when they are stored in bulk and explains why most of the corn and peas found in city markets lack the sweetness which is so characteristic of the home grown and freshly gathered article. If sweet corn must be picked one day and stored until the next morning before marketing, it should be spread out thinly over night on the ground or on the bottom of a cool cellar. A good average yield of sweet corn is from eight thousand to ten thousand marketable ears per acre. In market it is always sold by the dozen or hundred, but to canneries by the ton. Canneries make contracts in the spring with farmers for a given acreage at a stated price per ton delivered. A deduction is always made for husks and immature ears. This is based on a fair average of how the crop will run. While the canners generally buy corn by the ton, husks and all, there are occasional instances where it is

bought husked, the husking and silking being done by the factory.

Use of Sweet Corn Fodder—After picking the ears of sweet corn, the stalks are either cut and put in a silo or allowed to ripen, then cut, placed in shocks or stooks and fed in a dry state to cattle. In some sections the fodder is stored largely in silos and the milk business thereby expanded. In the fermentation process which corn fodder undergoes in the silo, the sugar is changed to starch, and if the silo is not perfectly airtight this changes again into acids which become very rank and strong, owing to excessive quantity. Although the stock seem to relish this sour silage, it oftentimes has an injurious effect upon the milk. But with a first-class silo and with the corn well cut and packed, the sweet corn fodder makes an excellent silage. The dry stalks make a rich, nutritious food, almost if not quite equal to timothy hay in feeding qualities, and are greatly relished by cattle. The stalks should be allowed to dry thoroughly in the field, then stored under cover in a dry place. Sweet corn stalks mold readily and spoil if at all damp.

In the selection of seed ears, they should be chosen from the very best stalks true to the type or variety, and either marked in the field or a strip left unpicked for this purpose. Select neither the very largest ears nor the smallest, but there is a general type which it is desirable to perpetuate and the ears nearest to this type are the ones that should be chosen. After maturing well, the best method is to pick the ears from the stalk, leaving a few husks attached, and tie a half dozen or more in a bunch. These bunches may be put astride a fence or strung up in a dry loft where there is plenty of air. Sweet corn retains moisture a long time and must not be stored away in bulk. If kept from the weevil it retains its vitality two years or more.

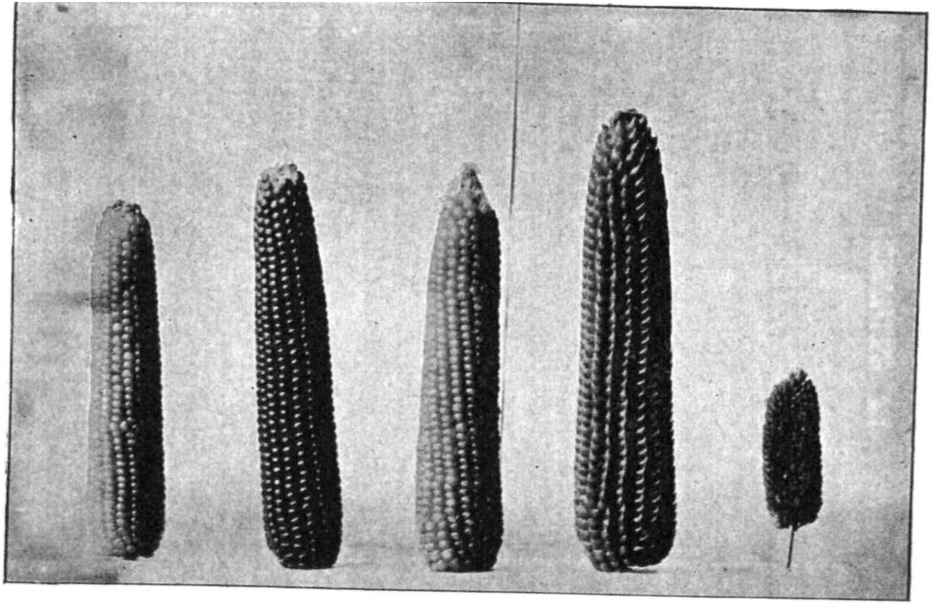


Fig 96—Varieties of Popcorn

Beginning at extreme left, these are in order as follows: White Pearl, Queen's Golden, Silver Lace, White Rice, Golden Tom Thumb

VARIETIES OF SWEET CORN

There are something like eighty varieties of sweet corn known to the American seed trade. Sturtevant in 1899 listed sixty-three varieties and in 1889 American seedsmen cataloged seventy-six varieties. Dr Sturtevant has divided sweet corn into three groups, according to the shape of the kernel. Seedsmen and growers generally classify it according to its period of ripening, there being the extra early, early or intermediate, general or main crop, and late. The illustrations (see Fig 95) from photographs of seed ears show some of the more popular varieties. The Cory is one of the most popular of the extra early varieties. It is eight-rowed, with good sized ears, large grains, but not of high quality, earliness being its great merit. Metropolitan, Marblehead and Minnesota are in this class, and like the early and extra early corns, the ears are of only medium size and the stalk from four to six feet tall. Perry Hybrid is a favorite market sort because of the large size of ear and stalk. This, with Crosby and Moore Concord, matures after Minnesota. The Early Adams and Extra Early Adams are not properly speaking sweet or sugar corns, but are grown extensively by market gardeners for early use.

For the general crop, Stowell Evergreen is preeminently the leader. The ears are of large size, kernels large and regular, and of fine quality. It produces abundantly, makes a large growth of stalk and has the merit of remaining green and in good condition for a long time. The late sorts, which are of large growth, are generally of superior quality. The Black Mexican, distinguished by the dark, almost black color of the grain or kernels, is very sweet in flavor. The Ne Plus Ultra or Shoe Peg produces ears of only medium size with kernels long and irregularly set.

The Country Gentleman, which is the same as this, except with larger ears, has become very popular in the past half dozen years. Egyptian is also popular.

For canning, Stowell Evergreen is the most popular and widely grown. Other popular sorts are Egyptian, Crosby Early and Country Gentleman. The extraordinary reputation of Maine canned corn is due to the Crosby variety. In that state a better yield and a finer quality of Crosby corn is grown than elsewhere, but it does not even there produce the quantity per acre that the Stowell does in New York and the western central states. Because of its superior quality and lighter yield per acre Maine growers usually get a better price per ton than New York, and western farmers.

Popcorn, known botanically as *Zea everta,* is a species group, characterized by the excessive proportion of the corneous endosperm and the small size of the kernels and ear. The best varieties have corneous endosperm throughout, which gives it the property of popping, a complete eversion or turning inside out of the kernel through the expansion of moisture contained within it, upon the application of heat. The best varieties of popcorn have but little or no deposit of starchy endosperm, which when in excess interferes with popping, as the kernel will merely split open or turn only part way. Popcorn is used largely by confectionery manufacturers for the making of popcorn balls, etc. It is also handled extensively by growers for family trade. Good crisp popcorn is not only appetizing but very nutritious.

THE CULTIVATION OF POPCORN

This differs but little from that of field or sweet corn. The valuable product is the ear, and the effort should be to produce as many of these on a stalk of as

good form and size as possible. Most varieties of popcorn incline to grow too much stalk at the expense of ear. To overcome this, only moderate quantities of fertilizer should be employed. The best results are obtained from plowing an old pasture and using commercial fertilizers made up largely of muriate of potash, broadcasted and harrowed in. Harrow the ground well and mark out in rows three to three and one-half feet apart, except for the dwarf kinds, and plant either in hills or drills. Two stalks to every foot is plenty. Use the weeder freely until the corn is eight to ten inches high. This not only keeps the ground mellow, conserves moisture and prevents weeds growing, but it also has a tendency to prevent a strong and rank growth of stalk.

When the corn is ripe, cut and place in small shocks or stooks, binding them tightly at the top with twine, weeds, straw or suckers without ears, in order to turn rain. Tie another band about midway between the tip and the butt, drawing it tight enough to keep the shock upright, but not so tight as to prevent the corn from drying out nicely. After drying, the corn should be husked in the field, or if drawn to the barn, it must be husked before rats and mice have opportunity to work it. The ears are then stored in well-ventilated cribs, and must be kept absolutely free from mice and rats. If these vermin get into popcorn they spoil its sale for popping purposes and it is useful only for hen feed. The corn must be kept dry, and is not generally fit for sale until the following year. Although popcorn can be, and often is, marketed the same season that it is grown, it does not give as good satisfaction in popping. A few damp days will utterly spoil it, so that it must be dried out again. During the summer care must be taken that it does not become so hot as to bake, as its popping qualities would be destroyed.

Marketing—Popcorn is commonly marketed by growers on the ear. A few dealers have worked up quite a business in shelling and putting it up in pound or quart pasteboard cartons, which are packed in cases and sold to grocers for family trade. Many grocers handle popcorn both in packages and in bulk on the ear. For corn in bulk, a better grade is always demanded. One well-known eastern packer who sells largely to grocers buys western popcorn for his package trade, but always the best crops of native grown for the trade in unshelled corn. Much of the western corn received in eastern markets is more or less shelled on arrival. Shelled popcorn kept in boxes through the hot weather is useless for popping. The corn gets too dry and will not expand enough in popping to evert it, but will split or crack. For this reason the trade for corn on the ear will always hold good, as corn of good popping quality can be kept only on the ear from one season to the next.

Twenty-five varieties of popcorn were cataloged by Sturtevant in 1899. However, not more than half a dozen of these are grown to any extent. The White Rice is most popular in market and more of this is grown than all others together. This variety is distinguished by the long, pointed, beaked kernel. There are several varieties of the Rice corn, which differ from the White in color only. These are the Red, Amber, Blush, Page Striped, Yellow, White's White, Monarch White and Bear Foot, the latter being a monstrous form and the others only color forms. The illustration (see Fig 96), from a photograph of seed ears, shows typical ears of some of the more popular varieties. The White Rice specimen was furnished by a Massachusetts grower who has made a specialty of this crop for fifteen years. This variety grows from five to seven feet tall and produces ears four to eight inches long.

Queen's Golden is another large-growing variety with yellow or orange-colored kernels. The ears are six and one-half to eight and one-half inches long and the stalks from six to eight feet tall. Silver Lace has ears five to six inches long and stalks six to seven feet tall. Mapledale Prolific is a very tall growing kind, sometimes attaining a hight of twelve feet. The stalks set several ears, varying from six to eight inches long. The kernels of these three varieties are smooth and rounded at butt. The Pearl is another popular tall-growing variety with smooth, rounded kernels but with smaller ears than the above. The California Golden is a dwarf variety growing from three to four feet tall and ears from two to three and one-half inches long. The kernels are beaked like the Rice corns and of an amber color.

There is great variation in different ears of the same variety grown in the same field, and it is only by long and careful selection that a strain can be obtained which will prove fairly uniform. From a strain not carefully bred, all shapes, sizes, and shades of color of ear and kernel will be produced, some with good popping qualities, and others lacking greatly in this respect. The yield, which is always estimated in pounds, varies from one thousand to two thousand pounds per acre and may run even higher in some varieties. A yield of fifteen hundred pounds per acre of Rice corn on the ear is considered a good, profitable acreage, but with less than one thousand pounds there is little profit in it. The price varies greatly, as the market for popcorn is limited, and it takes only a comparatively small quantity to overstock it. Prices in a wholesale way vary from one to four cents per pound.

CHAPTER XVIII

Maize in Other Countries

THE overshadowing importance of the United States in corn production tends to obscure the fact that the crop is grown in all quarters of the earth, and is an important crop and food resource in some part of each of the world's great continents. It is the cereal food of a vast population in the northern provinces of China, where famine stalks in the train of a crop failure; it is a staff of life in northern Italy and to a less extent in the valleys of the lower Danube; its green blades and golden tassels wave along the banks of the historic Nile, and it is having its part in the modern regeneration of the land of Joseph and Pharaoh. It is at home in the rich alluvial plains of the Rio de la Plata, and is the chosen food of the native sheep and cattle herders of northern Argentina, while in the great island continent of Australia it holds a small but not insignificant place in agricultural development.

For a series of years the contribution of the United States amounts to approximately seventy-five per cent of the recorded crop of the world, a proportion which during the past ten years has increased, rather than diminished, in spite of the fact that in some foreign countries the same period shows an increasing importance of the crop that almost indicates a revolution in agricultural practice. In 1893 the United States department of agriculture compiled a statement showing the corn crop in all countries of the world for which data were regularly available, making an average for what was practically the ten years preceding 1890 of 2,003,074,144 bushels, of which the United States fur-

nished 1,680,696,600 bushels. In addition, unofficial allowance was made for other producing countries, which swelled the total crop of the civilized world to "about 2,300,000,000 bushels." On this basis we produced in that decade about seventy-three per cent of the recorded supply.

STRONG POSITION MAINTAINED BY UNITED STATES IN WORLD'S TOTAL

During the decade just past the United States alone has grown in a single year a crop almost equaling the world's average production of the decade preceding, yet our proportion of the whole is still slightly under seventy-five per cent, and with our own maize land now practically all occupied, we have evidently reached a point where we may expect a diminishing figure to represent our proportion of the world's supply. Official figures covering all the countries included in the 2,300,000,000-bushel aggregate above quoted show an average world's crop, 1895 to 1899 inclusive, of 2,759,857,000 bushels, of which the United States contributed 2,257,062,000 bushels, or seventy-five per cent. Comparing these two statements of world production it will be seen that in the period ending with 1890 all countries other than the United States made an average annual contribution of 619,303,400 bushels, while for the five years ending with 1899 the contribution of the same countries was 702,995,000 bushels.

The crop of the world, as tabulated by the United States department of agriculture from reported official sources, is more fully shown in accompanying table in Appendix. The federal census figures of 1900, however, covering the year 1899, were eventually reported (in 1902) at 2,666,438,279 bushels, an amount materially greater than that here named. Considering the

snarp revision of official figures, increased acreage and consequent greater yield in the United States by the census of 1900, it has been necessary to make readjustment all along the line. The world's totals in recent years, therefore, must have been very much more than here indicated, and the figures are valuable chiefly in showing the relative distribution of corn growing in all countries.

OUR CHIEF COMPETITORS IN CORN CULTURE

It is obvious that this statement does not include all the countries of the world in which corn forms an important item of production, it being known that in

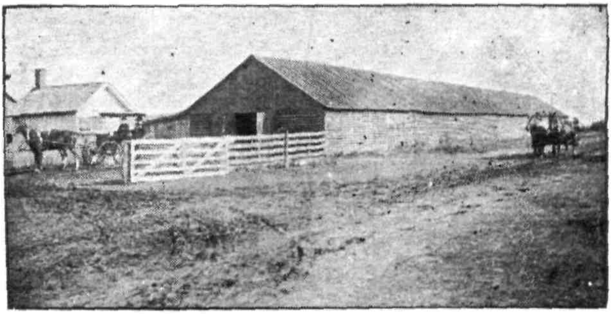


Fig 97—Corn Crib Which Holds 20,000 Bushels

This is the big crib in which the corn referred to in the text by Mr Maxon (see Page 161) was kept. It is an ordinary farm crib of great size covered with boards.

some omitted Central and South American countries this cereal forms an important part in the ordinary dietary of the people, while in northern China, in Japan, Cochin China and portions of India the crop is of local importance.

The Crop of Austria-Hungary—The dual empire takes second rank among corn-producing countries, with an annual average yield during the five years

ending with 1900 of 153,600,000 bushels. It is the leading cereal crop of the country and its volume shows marked increase in recent years. During the ten years ending 1890 the average crop was 110,000,000 bushels, showing an increase of forty per cent between the two periods. Hungary produces the great bulk of the crop, and it is in this division of the empire that its importance has increased so greatly in recent years.

While the country named ranks second in corn production, it consumes more than it grows, there being a net importation nearly every year, and the deficiency continues to increase in spite of the phenomenal gain in production during the recent years. The following statement shows the Austrian imports and exports in bushels of fifty-six pounds during the past decade:

MOVEMENT OF CORN INTO AND OUT OF AUSTRIA

Year	Imports	Exports	Year	Imports	Exports
1891	1,998,985	3,263,502	1896	4,728,636	899,654
1892	2,137,964	4,236,998	1897	9,099,662	742,074
1893	2,947,733	1,326,948	1898	26,181,028	119,044
1894	8,814,428	435,534	1899	6,098,470	132,620
1895	8,450,592	175,061	1900	7,190,139	84,982

Corn Culture in Mexico—Corn is the great cereal crop of Mexico, with a production in some years fully twelve times as great as wheat, its nearest grain rival. That country is also unique in that the original corn plant is still found there in its wild state. The crop is grown for domestic purposes only, and in years of ordinary results the production about suffices for home requirements. The domestic use is mainly as human food, and as it forms the principal grain food of the people any crop shortage is followed by correspondingly large importations from the United States. This importation in recent years has ranged from 154,644

bushels in 1901 to 8,825,860 bushels in 1897, following the partial crop failure of 1895 and 1896. The total crop of Mexico in recent years has ranged as follows: In 1893, 69,029,000 bushels; 1894, 77,273,000 bushels; 1895, 71,906,000 bushels; 1896, 76,264,000 bushels; 1897, 121,893,000 bushels; 1898, 111,347,000 bushels.

The most favored section of the country for the production of this crop is that lying south of the twenty-eighth degree of north latitude, in the states bordering on either the Gulf or the Pacific. Here the seasons are divided into wet and dry, and it is claimed

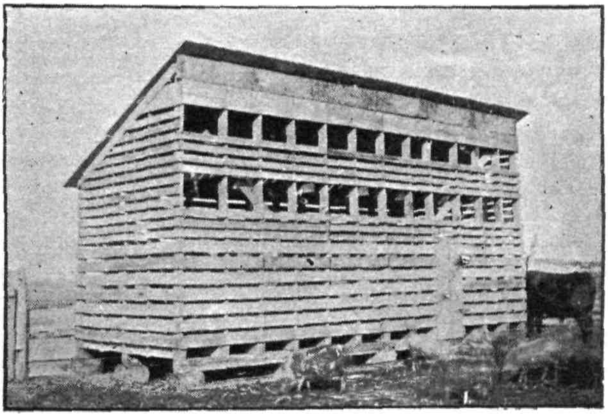


Fig 98—Small Corn Crib in Feed Lot

Sills are 8x8 inches, joists 2x8, studding 2x4, lower part of siding 1x6, upper part 1x4, roof common boards. The whole set on stone pillars. On farm of W. H. Provine, Christian County, Illinois.

that in some districts two crops can be raised from the same field in a single year. This may account for the heavy rates of yield that are occasionally claimed.

The states of principal production are Jalisco, on the Pacific coast, which with an area slightly larger than New York produced in 1898 a crop of 16,812,000

bushels. On the opposite coast the states of Vera Cruz, a narrow belt along the Gulf with an area a little over half that of Jalisco, produced 12,266,000 bushels, Guanajuato grew 10,934,000 bushels, and Michoacan 5,020,000 bushels. Other states of important production are Sinaloa, Hidalgo, Puebla, Oaxaca, Mexico and Yucatan. Available statistics of yield show that in the territory between the twenty-eighth and twenty-fifth degrees of north latitude the annual rate of yield varies considerably, indicating uncertain climatic conditions and especially tendency to drouth damage. South of the twenty-fifth parallel, especially in the coast states, the yield from year to year runs quite uniform, and it is in this district, where conditions are unusually perfect, that the largest part of the crop increase in recent years is centered.

The Crop of Argentina—The area of Argentina climatically fitted to the production of corn is better understood and much more circumscribed than in the case of wheat. Broadly speaking, it is limited to the northern part of the province of Buenos Aires and the adjoining southern part of Santa Fe and including a limited adjoining area in Cordoba and Entre Rios. This district represents the most fertile available land in the republic, and practically all the land where corn can be successfully grown one year with another. North of this district long summer drouths come too early and with too great regularity, while south, in western and southern Buenos Aires, rainfall is too irregular or the growing season too likely to be shortened by untimely frost.

The first agricultural development of Argentina was in the corn belt, and it is a striking fact that here agricultural occupation has been more permanent than in other districts of the country. In the wheat and flax sections the farming population has been unstable,

migratory in character, but in the corn belt cultivation has been systematic and agricultural improvement permanent. Conditions surrounding the growth of corn in Argentina are unusually favorable, and with agricultural methods careless in the extreme the rate of yield averages very little less than the average in the United States. With corn planted in drills, rows only twenty-four to thirty inches apart, usually cultivated but once or frequently not at all, yields of twenty to thirty bushels per acre are normal.

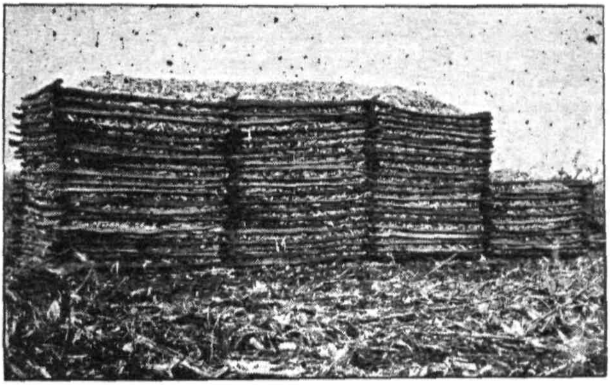


Fig 99—Corn in the Old Style Rail Cribs

The rails are 9½ to 10 feet long. Each crib holds 350 to 400 bushels. These cribs are in Christian County, Illinois, a few miles north of Taylorville. The photograph was taken in October, 1902, at the beginning of the husking season.

The great drawback to corn culture lies in the unfavorable climatic conditions for drying out the grain. The winter is a period of damp and frosty rather than dry cold weather, making it difficult to dry out the grain into merchantable condition. This failure to dry out makes it difficult and dangerous to handle or store Argentine corn, and the percentage of loss in cargoes during ocean voyage is very heavy. To some extent

this failure to secure corn dry enough for commercial handling is due to careless and ineffectual methods of farm handling after harvest, but even where the greatest possible care is exercised the unfavorable climatic conditions will remain as a severe handicap.

During the past few years, while the acreage devoted to wheat and flax has increased very rapidly, the importance of the corn crop has changed but little, furnishing ground for the opinion that Argentina is not likely to become in the near future a very important factor in the world's corn crop. Argentina agricultural statistics are scanty, and even when given as official are very unsatisfactory. No data of corn acreage by provinces later than 1895 are available, this being as follows:

ACREAGE UNDER CORN IN ARGENTINA

Province	Acres
Buenos Aires	1,653,116
Santa Fe	459,354
Cordoba	235,281
Entre Rios	179,694
Other	444,558
Total	2,972,003

The acreage of the crop of 1900, not given separately by provinces, aggregated only 3,074,374 acres, showing an increase in five years past of only 102,371 acres, or three per cent. The consumption of corn in Argentina is largely as human food, comparatively little being used as animal feed. This domestic use being about the same from year to year, the amount exported for a series of years will show with reasonable accuracy the varying production. The exports 1891 to 1901 were as follows:

ARGENTINA'S EXPORTS OF CORN

Year	Bushels	Year	Bushels
1891	2,594,706	1897	14,760,717
1892	17,555,569	1898	28,230,990
1893	3,212,965	1899	43,945,554
1894	2.160,358	1900	28,079,149
1895	30,404,615	1901	43,785,474
1896	61,828,113		

Russia—In comparison with other grains, corn occupies but an insignificant place in Russian agriculture, yet the acreage is steadily increasing, and there is abundant evidence that soil and climatic conditions in the southern portion of the empire are such as to permit of a great expansion in production. The rate of yield averages low, a fact which apparently may be due quite as much to poor methods of cultivation as to any natural condition. With corn apparently destined to occupy a higher permanent price level in the future, it is probable that Russia will become an increasingly important factor in the world's crop.

CORN CROP OF RUSSIAN EMPIRE

The following statement shows the acreage and production of corn in the Russian empire in recent years, according to official statistics of that government:

	European Russia		North Caucasus		Total		
Year	Acres	Bushels	Acres	Bushels	Acres	Bushels	Yield per acre
1895	1.917,621	24,940,476	379,135	6,752,692	2.296,756	31,693,168	14.2 bu
1896	2,185,350	17,178,434	366,976	6,594,312	2,552,326	23,772,746	9.3 bu
1897	2,211,543	45,488,291	384,734	6,477,268	2.596,277	51,965,559	20 0 bu
1898	2,351,606	39,529,435	435,262	8,388,082	2.786,868	47,917,517	17.2 bu
1899	2,406,081	22,640,741	479,604	8.271,554	2.885,685	30.912,295	10.7 bu
1900	2,709,430	25,569,934	559,043	8,686,528	3.268,473	34,256,462	10.4 bu
1901	....	56,542,400	....	7,098,400	....	63,640,000	....

It will be noted that in spite of the low rate of yield each year since 1895, the table relating to Russia's corn production shows a substantial enlargement in the corn acreage, and that between 1895 and 1900 the breadth of the crop increased by forty-three per cent. If the figures of production above quoted may be accepted as approximately correct, it appears that rather more than half of the Russian crop is exported, as shown in table in Appendix.

The Crop of Roumania—As in the case of the other Danubian countries, the acreage devoted to corn has increased rapidly in recent years, in spite of the low rate of yield usually secured. In the best years an average of twenty bushels per acre is rarely reached, and no crop of the country seems so subject to violent fluctuations of return. In 1894 the average yield was a trifle over twenty bushels per acre, while in 1895 the opposite extreme was reached with a return of but little more than five bushels. Despite this uncertainty, the acreage devoted to corn is already increasing. It was 4,184,372 acres in 1891; 4,560,230 in 1895, and 5,003,918 in 1900, an increase of nearly twenty per cent between the beginning and the close of the decade. The exports during the past decade may be noted in table in Appendix.

APPENDIX

Corn as a Nitrogen Gatherer

THE power of the maize plant to assimilate nitrogen from the soil, and to some extent from the air in the soil, and in the atmosphere, was demonstrated only after many years of experiment and scientific controversy. It cannot now be said that the whole subject is by any means fully understood, but certain principles have come to be generally accepted. And these principles have demonstrated the remarkable power of the corn plant as a restorative crop when grown in proper rotation.

Professor W. O. Atwater in 1876 inaugurated tests at the Connecticut agricultural experiment station to ascertain the truth or falsity of the above principles, which are now so generally accepted. Under his direction similar experiments were conducted by a large number of farmers throughout the country, in co-operation with the *American Agriculturist*. This was really the inception of scientific work among practical farmers that has since become so popular and had such an important influence. Atwater's work is set forth in great detail in the reports of the Connecticut board of agriculture and the United States department of agriculture. In 1881 he concluded:

"Of the ingredients of plant food in our soils, the most important, because the most costly, is nitrogen. Leguminous crops, like clover, do somehow or other gather a good supply of nitrogen where cereals, such as wheat, barley, rye and oats, would half starve for lack of it, and this in the face of the fact that leguminous plants contain a great deal of nitrogen, and cereals relatively little. Hence a heavy nitrogenous manuring may pay well for wheat and be in large part lost on clover."

This conclusion was directly opposite to the results at Rothamsted, England, for Dr J. B. Lawes had written in 1873 to the Massachusetts society for the promotion of agriculture that "the best possible manure for wheat, barley, maize, oats, sugar cane, rice and pasture grass is a mixture of superphosphate and nitrate of soda. Potash is generally found in sufficient quantities in soils, and an artificial supply is not required."

But in more than half of Atwater's experiments with corn, and in nearly all with potatoes, the crops were materially aided by potash salts, and without potash in the fertilizer

they often failed. "The corn almost universally refused to conform to nitrogen in fertilizers, and persisted in getting on well without any artificial supply. But it was largely benefited by phosphoric acid, and often by potash."

These results and concurrent investigations by other scientists and by many practical men, led some of the ablest agricultural writers of that time to champion the Atwater theory. Joseph Harris wrote in his book Talks on Manures: "We know less about the manurial requirements of Indian corn than almost any crop. The main question is the nitrogen supply—whether, like other cereals (wheat, barley, oats, grasses, etc), corn has but little power to get nitrogen from natural sources, and requires nitrogenous fertilizers, or whether, like leguminous plants (clover, beans, peas, etc), corn can gather the nitrogen for itself. That is, whether corn is an exhausting crop like wheat or a renovating crop like clover."

Summing up his work in 1881, Atwater concluded: "With the mineral fertilizers alone (phosphoric acid and potash) the corn crop gathered in these experiments some sixty pounds of nitrogen per acre. The important fact, however, is this: The corn plant has in these trials shown itself capable of getting on and bringing fair yields with but relatively small amounts of the less costly mineral fertilizers, even in the worn-out soils of the eastern states. With this help, corn has gathered its nitrogen from natural sources, and holds it readily to be fed out in the farm and returned in the form of manure for other crops. In other words, the experiments thus far imply that corn has somehow or other the power to gather a great deal of nitrogen from soil and air or both; that in this respect, it comes nearer to the legumes than the cereals. That in short, corn can be classed with the 'renovating' crops. If this is really so, and this can be settled only by continued experimenting, our great cereal, instead of being simply a consumer of the fertility of our soils, may be used as an agent for its restoration."

Professor Charles V. Mapes, "without whose interest and enthusiasm, as well as counsel and substantial help, the enterprise could not have succeeded as it has" (said Atwater in his official report), did much to popularize these results and promote their further verification. In a paper in the sixth annual report of the New Jersey state board of agriculture, 1878, Pages 79-167, Mapes emphasizes the exhaustive effect of wheat, barley and other dainty-feeding small grains as compared with renovating crops like clover and corn. He laid stress on the ability of clover, corn and turnips to "forage" successfully, but the other crops would fail, and sets up the following

CLASSIFICATION AND REQUIREMENTS OF CROPS

Group A: Wheat, barley, rye, oats, timothy hay, require first nitrogen, next phosphoric acid, last potash.

Group B: Corn, cotton, require first phosphoric acid, next potash, last nitrogen.

Group C: Peas, beans, clover, red clover, hay, require first potash, next phosphoric acid, last nitrogen.

In this table, corn in its demand for nitrogen as compared to potash and phosphoric acid is allied to clover rather than being classed with wheat, barley, oats, timothy hay, etc, as had been the rule previously.

The estimated cost for fertilizer required for growing these staple crops on average soils in this country was on the following basis: Phosphoric acid and potash, full quantities as shown by analysis to be contained in each crop, that is, full rations; nitrogen, one-half rations for wheat, barley, oats, meadow hay, one-quarter rations for corn and one-tenth ration for peas, beans and clover.

In the New Jersey report for 1879, Mapes reviewed Lawes's and Gilbert's manurial experimentation at Rothamsted for thirty years. For the total period the wheat crop received about 3540 pounds more nitrogen per acre in farm manure than in chemicals or concentrated fertilizers, and barley received 3021 pounds more nitrogen per acre in farm manure than in the concentrates. Yet in both experiments the results from the concentrated manures were equally good in every particular. What became of these differences in nitrogen, amounting in the two cases to 6551 pounds per acre, representing probably a value of $1200?

Dr Lawes replied (seventh report New Jersey board of agriculture) "that no subject has occupied our attention more than that with relation to the assimilation, accumulation or loss of nitrogen," and concludes that a considerable proportion of it is retained in the soil.

Mapes also emphasized that the plain superphosphate, even with the addition of potash, magnesia and soda, but without nitrogen, produced an average increase in the wheat crop of only one and one-quarter bushels per acre per annum above the yield from the natural unmanured soil. But when nitrogen was added, in the form of sulphate of ammonia, the yield went up from seventeen to thirty-five bushels as the average per annum per acre.

Dr Henry Stewart and others proved by their experience and writings that "if we had to supply all the nitrogen corn consumes, it would cost more to grow the crop than it would come to," whether the nitrogen were supplied in the form of manure or of fertilizers. Stewart pointed out (eighth report New Jersey board of agriculture, 1881) that, since it was neces-

sary to supply for corn on poor land only half the nitrogen it consumed, it would take no more nitrogen to raise one hundred bushels of corn on one acre than thirty-five bushels of wheat. Stewart maintained that the totally inadequate nitrogenous manure used, resulting in large crops, conclusively demonstrated that corn is able to get its nitrogen from some occult source, when the crop is sufficiently provided with potash and phosphoric acid.

The last article in this controversy by Dr Lawes (ninth report New Jersey board of agriculture, 1882) says: "At the same time, while I think that corn (maize) in common with the other cereal crops is dependent upon a liberal supply of nitric acid in the soil, I must not in saying this be supposed to advocate its application artificially. I quite agree with Dr Stewart in thinking that mineral manure alone (phosphoric acid, potash, etc) should be used with the addition of a small quantity of nitrogen, so long as they enabled the farmer to grow one hundred bushels of corn, or even a much smaller crop than that, per acre. The only difference between Dr Stewart and myself is this: I think that it is to the soil rather than to the atmosphere that we must look for the supply of nitrogen; while Dr Stewart's view is that the poverty of his soil does not admit of so large a supply of nitrogen being yielded."

Dr Lawes concludes: "Corn is a giant among the other grain crops, and for me has a peculiar fascination. I have already called attention to the remarkable advantage which corn possesses over the other cereal grain crops in that it continues growing throughout the summer and ripens in the autumn, but, at the time of writing, I was not so fully impressed as I now am with the great value of temperature for the production of nitric acid in the soil.

"With corn, the most vigorous growth and the most active assimilation of food take place just when nitrification is most active, but when the other cereal crops have done their work. No wonder then that the average yield of corn is much above that of other cereals. At the same time, although corn has access to sources of food in the soil which are not available for other grain crops, still the food itself must come out of the soil."

CORN AS A RESTORATIVE CROP

Out of the above controversy and by much successful experience among practical farmers extending over the past twenty years, the conclusion is now coming to be generally accepted that in a proper rotation of crops, but with a minimum of manure or fertilizer, the corn crop may be extremely useful in not only maintaining but in restoring the soil's fertility.

"On the comparatively light and poor soils of New Jersey, the land has for many years and in numerous instances,

shown decided improvement due to a rotation of corn, potatoes, wheat, timothy and clover. Stable manure is plowed under for the corn crop, which puts the soil and the manure in prime condition for the potatoes to follow. The potatoes are heavily dressed with commercial fertilizer, which so increases the yield and quality that the potatoes pay a handsome profit above cost of fertilizer. No manuring of any kind is done for the succeeding crops of wheat, timothy and clover. If, instead of using 1500 pounds of fertilizer on the potatoes, these farmers should use 500 pounds on the potatoes, 500 on the wheat and 500 on the grass, their bills would be as high as now, the labor three times as great, and their crops of potatoes cut down nearly one-half, with but a small increase in grain and hay. It is because potatoes are a money crop of the farm that they are fed on the choicest food. The corn plant is the key-keeper of the rotation. Clover supplies the crude material and corn manufactures it into suitable humus for the potato plant, yielding its grain as almost clear gain. On a rotation of this kind, corn is quite as important as the clover, because of its ability as a weed cleaner, and also because stable manure should first be 'strained through a crop of corn' before being used on potatoes."

As H. W. Collingwood points out, "one great advantage of this system is, that all the farm manure is used on the corn instead of on wheat or other crops." The hot summer is particularly favorable for the action of the chemical [and bacteriological] processes of the soil, including nitrification (changing of inert nitrogen into active nitrate or ammonia), and in converting farm manure and all coarse materials in the soil into available plant food. Corn, during its long summer growth, can freely use manurial supplies. Not so with wheat, for its growth stops soon after the corn crop has fairly started growing."

Wheat and Corn Compared

It is a difficult matter to arrive at a fair basis for an intelligent comparison of two such dissimilar crops as wheat and corn. Consultation with experiment station workers and others indicates that a wheat crop yielding fourteen bushels per acre will contain about 1400 pounds of straw of a given water content. In like manner, twenty-five bushels of shelled corn may be produced on an average of 3000 pounds of field cured corn fodder. While these two conclusions may therefore be taken to fairly represent average conditions in America, there are many wide variations from this standard.

Such a crop of wheat grown on one acre, also of corn, would have (under average conditions) about the composition below stated. (For explanation of the terms used, see note introduction to Table A, Appendix, on average composition of maize, and for computation of "manurial values" see Table B.)

Composition of the crops mentioned	14 bu wheat grain	25 bu corn grain	1400 lbs hay from wheat straw	3000 lbs hay from corn fodder	Total for wheat	Total for corn
Water, lbs per acre	84	154	168	1200	252	1354
Dry matter, lbs per acre	756	1246	1232	1800	1988	3046
Ash, lbs per acre..	15	21	52	49	67	70
Digestible protein, lbs per acre......	86	111	10	45	96	156
Digestible fiber, per acre.........	8	12	272	169	280	181
Digestible starch, per acre.........	526	886	283	432	809	1318
Digestible fat, per acre.............	14	60	6	21	20	81
Fuel value (calories).............	1,300,353	2,195,700	1,035,972	2,146,620	2,336,325	4,342,320
Nutritive ratio....	1 to 7	1 to 9	1 to 9	1 to 14	....	....
Feeding value, per acre.............	$7.31	$12.32	$6.58	$12	$13.89	$24.32
Nitrogen, lbs per acre..............	20	26	9	53	29	84
Phosphoric acid, lbs per acre......	8	10	17	16	25	26
Potash, lbs per acre	5	6	7	27	12	33
Manurial value, per acre....	$3.53	$4.48	$1.54	$9.60	$5.07	$14.08
Total value, per acre......	$9.07	$14.56	$8.12	$21.60	$7.19	$36.16

Now, having found out the yield per acre of green and crib-cured corn, and of dry matter, or real food elements, the next question is, what is the real value to the farmer of these crops? Dividing the crops into three great classes, and applying original data, *American Agriculturist* gets these results:

POUNDS OF DIGESTIBLE FOOD ELEMENTS IN 100 POUNDS OF CHEMICALLY DRY CORN

NAME OF FOOD ELEMENT	Eastern corn	Western corn	Southern corn
Cellulose or fiber	1.34	2.16	1.63
Fat or oil	5.03	4.57	5.63
Protein or albuminoids (nitrogenous matter)	10.78	10.26	10.33
Sugar, starch, etc (carbohydrates)	81.12	81.58	80.89
Mineral matter (lime, potash, phosphoric acid, etc)	1.73	1.53	1.52
Feeding value per 100 pounds	$1.17	$1.14	$1.18
Manurial value per 100 pounds	.34	.28	.33
Total value per 100 pounds	1.51	1.42	1.51
Feeding and manurial value per bushel of 56 pounds	.84	.79	.84

In this table, the composition of eastern corn is based on the average of seven analyses, made at the Massachusetts experiment station, of crops grown in the *American Agriculturist* competition; southern corn, average of five analyses, made at the South Carolina station, of prize crops grown in the state; western corn, Jenkins's statement. The feeding value is based on 4.2 cents per pound for fat or oil, 1.6 cents for the protein, and 0.96 cent per pound for the sugar, starch, fiber, etc. These are the average costs of the respective elements, at the market prices for feed sold in Connecticut last year, as determined by Jenkins. It may be assumed that the digestibility of all these corns is practically equal, and, therefore, that in all three classes of corn 34 per cent of the fiber, 76 per cent of the fat, 85 per cent of the protein and 96 per cent of the sugar and starch are digestible or available as food, under a judicious system of feeding. The manurial value is based on phosphoric acid at eight cents per pound, potash five cents, and nitrogen 16 cents; these elements often cost as much in ordinary commercial fertilizers. The total value per bushel is used for estimating the total feeding and manurial value of the prize crops in the large table of yields. It is an arbitrary basis of comparison, but is equally fair to all; it has nothing to do with the market or commercial value.

CHEMICAL COMPOSITION OF FEED STUFFS[a]

The average chemical composition of the grain, of the mill products, of the different parts of the plant, both green and dry, is shown in accompanying table:

	No of Analyses	Water %	Ash %	Protein %	Fiber %	Nitrogen free extract	Fat
Grain							
Dent—All analyses	86	10.6	1.5	10.3	2.2	70.4	5.0
Flint—All analyses	68	11.3	1.4	10.5	1.7	70.1	5.0
Sweet—All analyses	26	8.8	1.9	11.6	2.8	66.8	8.1
Pop varieties	4	10.7	1.5	11.2	1.8	69.6	5.2
Soft varieties	5	9.3	1.6	11.4	2.0	70.2	5.5
All varieties and analyses	208	10.9	1.5	10.5	2.1	69.6	5.4
Mill and waste products							
Corn meal—All analyses	77	15.0	1.4	9.2	1.9	68.7	3.8
Corn and cob meal	7	15.1	1.5	8.5	6.6	64.8	3.5
Corn cob	18	10.7	1.4	2.4	30.1	54.9	.5
Hominy chop	12	11.1	2.5	9.8	3.8	64.5	8.3
Corn bran	5	9.1	1.3	9.0	12.7	62.2	5.8
Corn germ	3	10.7	4.0	9.8	4.1	64.0	7.4
Corn germ meal	6	8.1	1.3	11.1	9.9	62.5	7.1
Cream gluten me l	..	10.1	.8	33.7	1.7	51.1	2.6
Chicago gluten meal	..	12.3	1.3	36.5	1.4	45.8	2.7
King gluten meal	..	7.4	.5	33.7	1.2	52.6	4.6
Gluten feed	11	7.8	1.1	24.0	5.3	51.2	10.6
Buffalo gluten feed	..	9.6	2.3	27.1	6.7	51.1	3.2
Peoria gluten feed	1	7.5	.8	19.8	8.2	51.1	12.6
Rockford gluten feed	..	8.9	.8	23.6	6.6	56.6	3.5
Chicago maize feed	3	9.1	.9	22.8	7.6	52.7	6.9
Glucose feed and refuse	2	6.5	1.1	20.7	4.5	56.8	10.4
Dried starch and sugar feed	4	10.9	.9	19.7	4.7	54.8	9.0
Starch feed, wet	12	65.4	.3	6.1	3.1	22.0	3.1
Corn fodder, green *b*							
Dent varieties	63	79.0	1.2	1.7	5.6	12.0	.5
Dent varieties, kernels glazed	7	73.4	1.5	2.0	6.7	15.5	.9
Flint varieties	40	79.8	1.1	2.0	4.3	12.1	.7
Flint varieties, kernels glazed	10	77.1	1.1	2.1	4.3	14.6	.8
Sweet varieties	21	79.1	1.3	1.9	4.4	12.8	.5
All varieties	126	79.3	1.2	1.8	5.0	12.2	.5
Leaves and husks, green	4	66.2	2.9	2.1	8.7	19.0	1.1
Stripped stalks, green	4	76.1	.7	.5	7.3	14.9	.5
Corn silage	99	79.1	1.4	1.7	6.0	11.0	.8
Corn fodder, field cured	35	42.2	2.7	4.5	14.3	34.7	1.6
Corn leaves, field cured	17	30.0	5.5	6.0	21.4	35.7	1.4
Corn husks, field cured	16	50.9	1.8	2.5	15.8	28.3	.7
Corn stalks, field cured	15	68.4	1.2	1.9	11.0	17.0	.5
Corn stover, field cured *c*	60	40.5	3.4	3.8	19.7	31.5	1.1

a Arranged from Jordan's The Feed of Animals—1901.

b By corn fodder is meant the en'ire plant, including the ear.

c By corn stover is meant the portion of the plant remaining after the ear is removed.

American Agriculturist Corn Contest

Many growers all over the United States competed in 1889 for prizes offered by the *American Agriculturist* (published by Orange Judd Company, New York) for the largest yield of corn on one measured acre—forty-three thousand five hundred and sixty square feet. The rules (as worked out by Herbert Myrick) were simple, uniform, and were rigidly adhered to, including surveying of land, witnessing harvest, weighing crop, etc. There was no room for error or fraud, the results were never questioned, and are accepted as a scientific demonstration of the possibilities of maize culture.

Thanks to the co-operation of the respective state agricultural experiment stations (except that the Iowa crops were analyzed by the United States department of agriculture), we are able to give, for the first time in the history of this crop, a concise statement not only of the yield of ear corn, kernels and cobs, with the percentage of each, but also the percentage of water in ear corn, kernel and cob. With this data it has been possible to ascertain (see the three columns 4, 5 and 6 in the table):

First, the number of bushels of shelled corn, in its fresh or green state, as husked.

Second, the number of bushels to which this green shelled corn would shrink, when kiln-dried until it contained only ten per cent of water, thus representing corn that has been kept in a dry crib for several months, until it will shrink no more.

Third, the number of bushels of chemically dry corn, with no water whatever in it. The farmer speaks of old, crib-cured corn as dry, but such grain contains at least ten pounds of water in every hundredweight. But the sixth column shows the number of bushels of chemically dry matter in the crops.

It is on the basis of dry matter that the crops are arranged in the table, and the prizes awarded. The dry matter, not the amount of water in a crop, measures its value. For instance, crop No 5, of one hundred and thirty bushels of shelled corn, green weight, being grown in Georgia, where the latter part of the season was quite dry, contained only sixteen per cent of water; the one hundred and thirty bushels, therefore, contained one hundred and ten bushels of chemically dry corn or dry matter. But crop No 7, from the moister Illinois climate, contained twenty-seven per cent of water in its kernels, so that its one hundred and thirty bushels of green or fresh corn yielded only ninety-five bushels of dry matter. Crop No 5, although apparently exactly the same size, really contained fifteen bushels more of actual corn.

PRIZE WINNING CROPS IN AMERICAN AGRICULTURIST CORN CONTEST OF 1889 (GROWN ON ONE ACRE)

	Percentage of			Bushels of Shelled Corn.						
	Shelled corn.	Dry matter in corn.	Dry matter in cob.	Green weight.	Crib cured.	Chemically dry.	Total expenses, dollars.	Value of unexhausted manure, dollars.	Net expenses per bushel, cents.	Feeding and manurial value of crop, dollars.
	1	2	3	4	5	6	7	8	9	10
1. Zachariah Jordan Drake, Marlborough Co, S C; see full descriptive article, Page 172........	82	85	87	255	239	217	264	158	44	182
2. Alfred Rose, Yates Co, N Y; land, sandy loam; fertilizer, 800 pounds Mapes corn manure; variety, Early Mastodon; one kernel every foot in rows 3 feet apart......	74	83	68	213	191	174	62	16	16	146
3. George Gartner, Pawnee Co, Neb; land, black rich loam; fertilizer, barnyard manure, 90 loads; variety, Early Mastodon; hills, 3 x 3 feet..............................	84	80	65	171	151	137	87	2	47	108
4. J. Snelling, Barnwell Co, S C; land, sandy loam; fertilizer 300 bushels stable manure, 300 bushels cotton seed; variety, White Gourd; hills, 1 x 4 feet........................	84	85	87	131	122	111	57	19	33	93
5. W. L. Peck, Rockdale Co, Ga; land, sandy loam; fertilizer, 4 wagon loads stable manure, 30 bushels heated cotton seed, 1000 pounds Packard standard fertilizer, 500 pounds cotton seed meal; variety, large white corn; hills, 5-6 x 4 feet..................................	80	84	75	130	121	110	46	7	32	92
6. B. Gedney, Westchester Co, N Y; land, clay loam; fertilizer, 800 pounds Mapes corn manure; variety, King Philip; hills, 1/4 x 3 1/2 feet..................................	79	85	65	119	112	102	131	71	54	86
7. E. P. Kellenberger, Madison Co, Ill; land, sandy loam; no fertilizer; variety, Eclipse (early yellow dent); hills, 5-6 x 2 1/2 feet....	83	73	40	130	105	95	26	15	30	75
8. H. M. Kersey, Marshall Co, Ia; land, dark rich loam; fertilizer, 29 loads stable manure; variety, Nebraska dent; hills, 1 1/3 x 2 feet....	84	91	84	100	100	91	15	8	23	72
9. L. S. Wells, Hartford Co, Ct; land, heavy sandy loam; fertilizer, 60 loads stable manure, 30 bushels hen manure, 600 pounds bone, 200 pounds nitrate of soda, 200 pounds muriate of potash, 20 bushels wood ashes; variety, Clark's Early Mastodon; hills, 3 1/2 x 3 1/2 feet.....	80	82	65	110	99	90	132	66	23	76

	Percentage of			Bushels of Shelled Corn.						
	Shelled corn.	Dry matter in corn.	Dry matter in cob.	Green weight.	Crib cured.	Chemically dry.	Total expenses, dollars.	Value of unexhausted manure, dollars.	Net expenses per bushel, cents.	Feeding and manurial value of crop, dollars.
	1	2	3	4	5	6	7	8	9	10
10. **E. W. Lupton, Berkeley Co, W Va**; land, clay loam; fertilizer, 5 cords stable manure; variety, Cloud's early dent and a mixture of yellow corn; hills, $1 \times 3\frac{3}{4}$ feet.....	80	82	66	107	95	88	31	4	38	74
11. **P. C. Hiller, Lancaster Co, Pa**; land, clay and sand mixed; fertilizer, 600 pounds special fertilizer; variety, a local corn, Improved Chester Gourd; hills, $1\frac{1}{2} \times 3\frac{1}{3}$ feet	77	72	48	120	96	87	27	8	47	73
12. **E. R. Towne, Washington Co, Vt**; land, gravelly; fertilizer, 78 loads barnyard manure; flint variety of his propagation; 2 and 3 kernels every 6 inches; rows, $2\frac{1}{2}$ feet..	78	69	42	124	94	85	117	80	40	71
13. **Morris C. Smith, Linn Co, Ia**; land, sandy loam; fertilizer, 22 loads barnyard manure; variety, a mixture of several kinds; hills, 2 x 3 5-6 feet............................	82	92	77	91	91	84	33	7	45	66
14. **R. T. Gillespie, York Co, S C**; land, mucky loam; fertilizer, 1200 pounds acid phosphate, 500 pounds kainit, 500 pounds cotton seed meal; variety, large white corn; hills, $1\frac{1}{2} \times 1\frac{1}{2}$ feet....................	81	76	64	109	92	83	37	4	36	70
15. **Jacob S. Pfrinner, Harrison Co, Ind**; land, sandy loam; fertilizer, 500 pounds Lister's phosphate; variety, not stated; hills, 1 x 2 and 3 feet..................................	76	80	65	106	90	82	25	5	34	65
16. **Henry Campbell, Monmouth Co, N J** land, clay loam; fertilizer, 18 loads stable manure; variety, Ohio Gourd; hills, 1 x 4 feet........	78	70	55	117	90	82	49	4	50	69
17. **D. Pence, Fairfield Co, O**; land, black muck; fertilizer, 190 pounds Bowker's, 12 loads barnyard manure, salt; variety, yellow dent; hills, 1 5-6 x 3 feet............	82	70	51	115	90	82	33	7	45	65
18. **J. M. Graham, Hickman Co, Tenn**; land, clay loam; fertilizer, 300 bushels ashes, 500 pounds Tennessee guano, and barnyard manure; variety, dent corn; hills, 3 x 3 feet..............................	81	83	67	97	89	81	72	26	52	68

	Percentage of			Bushels of Shelled Corn.						
	Shelled corn.	Dry matter in corn.	Dry matter in cob.	Green weight.	Crib cured.	Chemically dry.	Total expenses, dollars.	Value of unexhausted manure, dollars.	Net expenses per bushel, cents.	Feeding and manurial value of crop, dollars.
	1	2	3	4	5	6	7	8	9	10
19. A. L. Griffith, Monroe Co, O; land, brown and yellow clay loam; fertilizer, 50 bushels wood ashes, 200 pounds Mapes raw bone, 100 pounds Mapes corn manure, 300 pounds Buckeye superphosphate, 50 pounds ammoniated superphosphate, 40 loads barnyard manure; variety, Golden Beauty; hills, 1 x 3½ feet	80	75	60	106	87	80	60	19	47	63
20. R. M. Allison, York Co, S C; land, sandy loam; fertilizer, 7500 pounds barnyard manure, 175 pounds Farmers' Alliance guano, 400 pounds Edisto, 600 pounds wood ashes, 4 bushels lime in salt; variety, Maryland; hills, ½ x 4 feet	86	80	82	100	88	80	66	26	47	67
21. M. H. Carraway, Harrison Co, O; land, clay loam; fertilizer, 40 loads stable manure; variety of his own propagation; hills, 2½ x 3½ feet	77	73	63	113	87	79	40	3	44	62
22. Henry Butler, Washington Co, Kan; land, black loam; fertilizer, 600 pounds Mapes corn manure; variety, Calico corn, hills, 1 x 3 feet	82	83	83	95	87	79	25	4	25	62
23. R. M. Allison, York Co, S C; land, sandy loam; fertilizer, 7500 pounds stable manure, 200 bushels cotton seed, 20 sacks unleached ashes, 2 sacks guano; variety, Garratt; hills, irregular widths by 5 feet	78	75	70	104	86	78	79	35	41	66
24. Abel Allen, Jr, Caldwell Co, Mo; land, black prairie loam; fertilizer, barnyard manure; variety, white dent; hills, 1 x 3 5-6 feet	79	80	50	95	84	70	15	12	33	60
25. E. M. Williamson, Darlington Co, S C; land, sandy loam; fertilizer, 600 pounds cotton seed meal, 600 pounds dissolved bone, 300 pounds kainit, 200 pounds Edisto ammoniated; variety, Williamson; hills, 1¼ x 1¼	87	86	90	87	83	75	64	35	35	63
26. J. C. Miller, Fairfield Co, O; land, clay and black loam; fertilizer, 300 pounds Crocker's wheat and corn phosphate; variety, yellow dent; hills, 1 to 1¼ x 3½ feet	82	81	68	96	79	72	25	2	34	57

	Percentage of			Bushels of Shelled Corn.						
	Shelled corn.	Dry matter in corn.	Dry matter in cob.	Green weight.	Crib cured.	Chemically dry.	Total expenses, dollars.	Value of unexhausted manure, dollars.	Net expenses per bushel, cents.	Feeding and manurial value of crop, dollars.
	1	2	3	4	5	6	7	8	9	10
27. Ira L. Hershey, Lancaster Co, Pa; land, sandy clay loam; fertilizer, 6 cords hog manure, 1700 pounds South Carolina phosphate, 200 pounds land plaster; variety, Golden Beauty; hills, 3 x 4 feet.....	79	71	43	110	78	71	61	23	49	60
28. J. N. Muncey, Buchanan Co, Ia; land, sandy loam; fertilizer, 31 loads barnyard manure; variety, Goddard's King of the Earliest; hills, ½ x 3 to 3 5-6 feet............	87	91	84	77	77	70	34	6	37	55
29. Fonshee J. Tebbs, Harrison Co, Ky; land, black loam; fertilizer, none; variety, not stated; hills, 1 x 3 feet............................	82	75	78	92	76	69	21	8	37	60
30. John C. Dillon, Hampshire Co, Mass; land, sandy loam; fertilizer, 12 loads barnyard manure; varieties, Pride of the North and Horton's Favorite; hills, 1 7-12 x 3 1-6 feet.............................	81	67	33	102	75	68	97	40	76	57
31. A. H. White, York Co, S C; land, clay loam; fertilizer, 262 loads stable manure, 1400 pounds cotton seed meal, acid phosphate and kainit mixed, and 760 pounds soluble and guano; variety, his own propagation; hills, 1½ x 2¼ feet......	89	86	85	79	75	68	84	36	64	57
32. Joseph S. Wells, Hampshire Co, Mass; land, clay loam; fertilizer, 1250 pounds Chittenden's complete tobacco manure; variety, Leaming; hills, 3 x 3 feet..........	78	67	45	101	74	67	106	54	71	56
33. Edwin Harper, Georgetown Co, S C; land, a pine plain; fertilizer, 100 cartloads hog manure, 120 bushels green cotton seed; variety, Hick's Gourd seed-corn; hills, 1 x 6 feet.....................	83	87	85	76	73	66	49	16	46	55
34. Alfred Fuller, Cattaraugus Co, N Y; land, black loam and fine gravel; fertilizer, 30 loads stable manure; variety, yellow flint; hills, not stated..................	77	60	40	109	72	65	46	5	57	55
35. W. S. Westcott, Hampshire Co, Mass; land, strong gravelly loam; fertilizer, 10 cords stable manure, 600 pounds Stockbridge; variety, yellow flint; hills, 1 7-12 x 3 1-6 feet............................	79	77	57	84	72	65	129	60	96	55

	1	2	3	4	5	6	7	8	9	10
36. Frank Goodwin, Middlesex Co, Mass; land, clay loam; fertilizer, 7 cords barnyard manure, 900 pounds Bradley's phosphate, 2 barrels lime; variety, Longfellow; hills, 3 x 3½ feet....................	79	70	54	89	67	61	133	56	115	51
37. William H. Tarbox, Kent Co, R I; land, loam; fertilizer, 19 loads barnyard manure, 21 loads barnyard dirt, 20 loads sink drain, 2 loads hen manure and sand, 400 pounds Bradley's phosphate; variety, Sanford; hills, 1 to 1½ x 3½ feet....................................	79	82	53	75	66	60	55	15	62	50
38. Henry Tillson, Franklin Co, Mass; land, sandy loam; fertilizer, 1800 pounds Quinnipiac phosphate; variety, early yellow dent; hills, 5 6 x 3 feet.	84	71	53	84	66	60	67	21	70	50
39. Ezra Michener, Bucks Co, Pa; land, sandy clay loam; fertilizer, 10 loads barnyard manure; variety, no distinct variety; hills, 1¼ x 3 feet............................	75	76	58	75	63	57	56	20	58	48
40. E. J. Grover, Milwaukee Co, Wis; land, black and sandy loam; fertilizer, 5 cords barnyard manure; variety, yellow dent; hills, not stated......................	76	63	50	89	61	56	26	2	47	44
41. George P. Smith, Franklin Co, Mass; land, alluvial soil; fertilizer, 15 loads stable manure, 800 pounds Quinnipiac phosphate; variety, yellow flint; hills, 3⅓ x 3⅓ feet................................	79	78	44	65	56	51	80	29	92	43
42. E. A. Robinson, Johnson Co, Ind; land, clay loam and muck; fertilizer, 10 loads barnyard manure, 10 barrels hen manure; variety, Early Mastodon; hills, 3⅔ x 1 5-6 feet............................	80	78	58	65	56	51	33	1	57	40
43. Charles J. Tilden, Hartford Co, Ct; land, clay loam; fertilizer, 1600 pounds Mapes corn manure; variety, yellow flint; hills, 1 x 3 feet	81	80	58	62	55	50	59	23	64	42
44. Henry Wood, Richland Co, S C; land, sandy loam; fertilizer, 2 sacks Stone's acid phosphate, 2 sacks Azolite top dressing, 2 sacks cotton seed meal, lime, salt, 1 sack kainit, 28 one-horse loads stable manure; variety, Adam's early; hills, not stated.....................	75	81	90	51	46	42	66	30	80	35
45. James McCutchen, Williamsburg Co, S C; land, sandy loam; fertilizer, 555 bushels sheep's manure, a mixture of 120 bushels green cotton seed, 320 pounds acid phosphate, 160 pounds kainit; variety, Hickory King; hills, 1¾x3½ feet...	90	87	88	59	45	41	30	89	68	34
Average of the entire 45 crops......	80.5	78	63	104	89	81	34	2	34	66

COMPARISON BETWEEN THE AVERAGE RESULTS OF THE CONTEST CROPS IN THE EASTERN, SOUTHERN AND WESTERN STATES

PLATS OF ONE EXACT ACRE EACH	Eastern 17 crops	Southern 14 crops	Western 14 crops
Weight of green corn on ear	7,384	7,178	7,139
Per cent of shelled corn	78	83	81
Pounds of shelled corn	5,748	5,910	5,766
Per cent of cob	21	17	19
Pounds of cob	1,594	1,274	1,363
Per cent of dry matter in kernels	74	81	79
Pounds of dry matter in kernels	4,273	4,834	4,549
Per cent of dry matter in cob	52	7,976	64
Pounds of dry matter in cob	868	993	805
Per cent of water in corn on ear	31	18	24
Pounds of water in corn on ear	2,229	1,346	1,785
Bushels of shelled corn green as harvested	103	106	104
Bushels of crib-cured or kiln-dried shelled corn	84	95	87
Bushels of actually dry matter in shelled corn	76	86	81
Total feeding and manurial value of the crop	$64	$72	$64

IMPORTS OF CORN INTO VARIOUS COUNTRIES

[IN BUSHELS]

Calendar Years	United States *a*	United Kingdom	France	Germany	Belgium	Holland	Spain
1901	5,169	102,745,600	11,601,428	46,978,408	14,944.751	18,639,106	2,671,093
1900	2,480	108,303,140	13.011,518	54.491,801	20,729,991	25,134,518	*b*
1899	4,171	125,482,700	20,552,330	64,036,148	20,429,683	29,034,795	2,829,615
1898	3,417	114,338,584	22,075,636	62,224,833	18,060,210	27,655,441	4,253,001
1897	6,284	107,570,760	15,609,556	49,852,174	15,514,136	20,155,704	*b*
1896	4,338	103,544,200	12,981,531	32,335,118	13,021,562	17,437,024	*b*
1895	16,575	67,888,700	5,359,534	12,748,510	8,116,857	7,687,590	*b*
1894	2,199	70,730,086	9,848,097	22,958,637	*b*	8,105,436	*b*
1893	1,881	65,805,006	12,845,179	29,962,333	*b*	12,475,620	*b*
1892	15,290	70,762,448	8,744,834	28,239,222	*b*	10,953,035	*b*
1891	2.111	53,651,250	3,284,407	16,075,089	*b*	6,176,020	*b*
1890	1,626	86,875,668	26,208,944	22,122,287	*b*	8,209,406	*b*

a Year ended June 30. *b* Figures not available.

TABLE A—COMPOSITION OF MAIZE, GRAIN AND FODDER, COMPARED WITH OTHER FORAGE

The following tables were compiled by Herbert Myrick from all American analyses available at that date. **They give** the average of all these analyses for all varieties. From these means there are wide variations. **The coefficients of digestibility** employed were also the average of all American work. The feeding value expressed in money has no relation to selling price, but affords an empirical basis for comparison, being obtained by allowing one cent for each pound of digestible nitrogen free extract (sugar, starch, gums, etc), and two cents for each pound of digestible protein and fat. Manurial values in money are got by estimating nitrogen as worth fifteen cents per pound, phosphoric acid five cents, potash four cents. Allowing that one-half of the manurial value is lost in handling the crop or feeding it, adding the other half to the feeding value, we get the so-called "total value expressed in money."

TABLE A—COMPOSITION OF FEEDING STUFFS

FEEDING STUFF	WATER	DRY MATTER	ASH	PROTEIN		FIBER		NITROGEN FREE EXTRACT		FAT		FUEL VALUE	NUTRITIVE RATIO	FEEDING VALUE
				Total	Digestible	Total	Digestible	Total	Digestible	Total	Digestible	Calories	1 to	Per 100 lbs
Green Fodders														
Corn fodder	79	21	1.2	1.8	1.1	5.0	3.1	12.2	9.0	.5	.4	26,076	11.8	$0.15
Oat fodder	62	38	2.5	3.4	2.7	11.2	8.8	19.3	13.5	1.4	1.0	51,624	9.1	.29
Timothy (average)	62	38	2.1	3.1	2.3	11.8	6.6	20.2	13.3	1.2	.8	51,591	9.4	.26
Red clover	71	29	2.1	4.4	3.1	8.1	4.3	13.5	10.5	1.1	.7	36,187	5.3	.22
Alfalfa	72	28	2.7	4.8	3.9	7.4	4.1	12.3	8.1	1.0	.4	29,798	3.4	.20
Soja bean	75	29	2.6	4.0	2.8	6.7	3.7	10.6	5.5	1.0	.6	29,833	3.8	.16
Dried Fodders														
Corn silage	79	21	1.4	1.7	.6	6.0	4.0	11.0	7.7	.8	.7	25,714	22.0	$0.14
Corn fodder	42	58	2.7	4.5	2.5	14.3	9.4	34.7	24.0	1.6	1.2	71,554	14.0	.40
Corn stover	41	59	3.4	3.8	2.0	19.7	13.0	31.5	20.2	1.1	.6	67,766	17.2	.38
Hay from														
Timothy	13	87	4.4	5.9	2.9	29.0	15.4	45.0	28.4	2.5	1.4	92,729	16.1	$0.52
Red clover	15	85	6.2	12.3	6.6	24.8	11.9	38.1	23.2	3.3	1.7	84,995	5.8	.56
Alfalfa	8	92	7.4	14.3	10.6	25.0	11.5	42.7	29.0	2.2	1.4	94,936	4.1	.64
Wheat straw	10	90	4.2	3.4	.8	38.1	22.1	43.4	23.0	1.3	.5	73,998	57.6	.47
Oat straw	9	91	5.1	4.0	1.6	37.0	21.5	42.4	22.5	2.3	.7	83,493	28.4	.48
Soja bean	10	90	5.8	4.6	2.3	40.4	24.6	37.4	25.8	1.7	1.0	82,987	2.3	.57

Roots																
Potatoes	79	21	1.0	2.0	1.3	.5	.2	16.3	14.8	.1	.0	31.360	11.5	$0.15
Beets	87	13	.9	1.8	1.2	.9	.1	9.8	1.0	.1	.1	18,904	1.1	.03
Mangel-wurzels	91	9	1.1	1.4	1.0	.9	.4	5.5	5.0	.2	.1	12,888	5.6	.07
Turnips	90	10	1.7	2.1	.8	2.1	.2	13.5	12.9	.1	.1	13,986	16.5	.13
Ruta-bagas	88	11	1.2	1.2	.9	1.3	1.0	7.5	7.1	.2	.1	16,497	9.2	.10
Carrots	88	11	1.0	1.1	.8	1.3	.0	7.6	7.1	.4	.2	16,999	9.3	.09
Grains and Other Seeds														
Corn	11	89	1.5	10.5	7.9	2.1	.9	69.6	63.3	5.4	4.3	156,836	9.3	$0.88
Barley	11	89	2.4	12.4	8.7	2.7	1.3	69.8	60.7	1.8	1.6	143,499	7.5	.82
Oats	11	89	3.0	11.8	9.3	9.5	4.6	59.7	52.0	5.0	4.2	124,757	7.0	.83
Rye	12	88	1.9	10.6	9.1	1.7	.8	72.5	63.1	1.7	1.4	152,400	7.4	.84
Wheat (all varieties)	11	90	1.8	11.9	10.2	1.8	.9	71.9	62.6	2.1	1.7	154,848	6.6	.87
Cotton seed (whole)	10	90	3.5	18.4	11.1	23.2	17.4	24.7	12.4	19.9	18.4	160,047	6.3	.88
Mill Products														
Corn meal	15	85	1.4	9.2	7.0	1.9	1.1	68.7	63.2	3.8	3.3	148,026	10.2	$0.84
Corn and cob meal	15	85	1.5	8.5	6.5	6.6	3.0	64.8	57.0	3.5	2.9	128,808	10.2	.78
Oatmeal	8	92	2.0	14.7	11.5	.9	4.0	67.4	59.3	7.1	5.9	143,302	6.6	.98
Barley meal	12	88	2.6	10.5	7.4	6.5	3.3	66.3	58.3	2.2	2.0	138,818	8.9	.80
Ground corn and oats	12	88	2.2	10.6	7.4	5.5	3.0	67.2	58.0	3.5	3.0	143,276	9.2	.82
Pea meal	11	90	2.6	20.2	16.8	14.4	3.7	51.1	48.0	1.2	.7	130,246	3.2	.86
Waste Products														
Gluten feed	8	92	1.1	24.0	20.4	5.3	2.3	51.2	41.5	10.6	8.6	155,569	3.1	$1.01
Gluten meal	8	91	.9	29.3	25.5	3.3	1.1	46.5	42.3	11.8	10.4	169,930	2.5	1.15
Hominy chops	11	89	2.5	9.8	7.5	3.8	1.6	64.5	52.2	8.3	6.8	145,342	9.1	.82
Malt sprouts	10	90	5.7	23.2	18.7	16.7	3.5	48.5	33.0	1.7	1.2	120,624	2.1	.76
Brewers' grains (wet)	76	24	1.0	5.4	4.0	3.8	1.5	12.5	8.0	1.6	1.4	30,692	3.1	.20
Brewers' grains (dried)	8	91	3.6	19.9	14.7	11.0	5.8	51.7	30.5	5.6	4.8	115,814	3.2	.75
Rye bran	12	88	3.6	14.7	11.5	3.5	3.2	63.8	47.9	2.8	2.0	123,089	4.8	.78
Wheat bran	12	89	5.8	15.4	12.0	9.0	2.3	53.9	36.7	4.0	2.9	111,138	3.8	.68
Wheat middlings	12	84	3.3	15.6	12.8	4.6	1.5	60.4	53.2	4.0	3.4	136,996	4.8	.87
Wheat shorts	12	88	4.6	14.9	12.2	7.4	2.7	56.8	49.4	4.5	3.8	131,855	4.9	.75
Buckwheat middlings	13	87	4.8	28.9	17.3	4.1	1.4	41.9	36.9	7.1	4.5	100,850	2.7	.81
Cottonseed meal	8	92	7.2	42.3	37.0	5.6	1.8	23.6	15.1	13.1	12.6	152,653	1.2	1.16
Cottonseed hulls	11	89	2.8	4.2	.4	46.3	16.8	33.4	13.4	2.2	1.7	65,480	84.8	.36

TABLE B—MANURIAL VALUE OF FEEDING STUFFS

NAME OF ARTICLES	NITROGEN	PHOSPHORIC ACID	POTASH	MANURIAL VALUE Per 100 lbs	TOTAL VALUE Per 100 lbs
Green Fodders					
Corn fodder	.41	.15	.33	$0.08	**$0.19**
Oat fodder	.49	.13	.38	.09	**.34**
Timothy (average)	.48	.26	.76	.11	**.33**
Red clover	.53	.13	.46	.10	**.27**
Alfalfa	.72	.13	.56	.13	**.27**
Soja bean	.29	.15	.53	.07	**.20**
Dried Fodders					
Corn silage	.42	.13	.39	$0.07	**$0.18**
Corn fodder	1.76	.54	.89	.32	**.56**
Corn stover	1.04	.29	1.40	.22	**.49**
Hay from					
Timothy	1.26	.53	.90	$0.25	**$0.65**
Red clover	2.07	.38	2.20	.41	**.77**
Alfalfa	2.19	.51	1.68	.42	**.85**
Wheat straw	.59	.12	.51	.11	**.53**
Oat straw	.62	.20	1.24	.15	**.56**
Soja bean	1.75	.40	1.32	.33	**.74**
Roots					
Potatoes	.21	.07	.29	$0.04	**$0.17**
Beets	.22	.10	.48	.05	**.06**
Mangel-wurzels	.19	.09	.38	.04	**.09**
Turnips	.18	.10	.39	.04	**.15**
Ruta-bagas	.19	.12	.49	.05	**.16**
Carrots	.15	.09	.51	.04	**.11**
Grains and Other Seeds					
Corn	1.82	.70	.40	$0.32	**$1.04**
Barley	1.51	.79	.48	.28	**.96**
Oats	2.06	.82	.62	.37	**1.02**
Rye	1.76	.82	.54	.32	**1.00**
Wheat (all varieties)	2.36	.89	.61	.42	**1.08**
Cotton seed (whole)	3.00	1.00	1.00	.54	**1.15**
Mill Products					
Corn meal	1.58	.63	.40	$0.28	**$0.98**
Corn and cob meal	1.41	.57	.47	.25	.91
Oatmeal	1.86	.77	.59	.34	1.15
Barley meal	1.55	.66	.34	.27	.94
Ground corn and oats	1.90	.69	.41	.33	.98
Pea meal	3.08	.82	.99	.54	1.13
Waste Products					
Gluten feed	3.72	.30	.01	$0.55	$1.29
Gluten meal	5.03	.33	.05	.77	1.54
Hominy chops	1.63	.98	.49	.31	.98
Malt sprouts	3.55	1.43	1.63	.66	1.09
Brewers' grains (wet)	.89	31	.05	.15	.28
Brewers' grains (dried)	3.62	1.03	.09	.59	1.05
Rye bran	2.32	2.28	1.40	.51	1.04
Wheat bran	2.67	2.89	1.61	.60	.98
Wheat middlings	2.63	.95	.63	.46	1.10
Wheat shorts	2.10	.76	.51	.37	.93
Buckwheat middlings	1.38	.68	.34	.25	.94
Cottonseed meal	6.64	2.68	1.79	1.20	1.76
Cottonseed hulls	.75	.18	1.08	.16	.44

Miscellaneous Tables

CORN CROP OF THE WORLD BY COUNTRIES

[IN ROUND MILLIONS OF BUSHELS]

	1896	1897	1898	1899	1900	1901
United States	2,284	1,903	1,924	2,078	2,188	1,419
Canada (Ontario)	25	25	24	22	28	25
Mexico	76	122	111	93	100	90
North America	2,385	2,050	2,059	2,193	2,316	1,534
Chili	9	8	10	9	8	8
Argentina	80	40	56	72	60	69
Uruguay	5	4	4	6	3	7
South America	94	52	70	87	71	84
France	30	30	23	26	22	..
Spain	18	20	14	25	24	..
Portugal	15	16	16	16	16	..
Italy	80	66	80	89	83	86
Austria-Hungary	164	133	164	145	162	145
Roumania	65	80	102	28	85	112
Bulgaria and E Roumelia	26	25	38	20	36	30
Servia	16	16	25	15	24	..
Russia	24	52	48	31	34	66
Europe	438	438	510	395	486	..
Egypt	34	35	32	30	20	30
Cape Colony	2	3	2	3	2	2
Africa	36	38	34	33	22	32
Australasia	10	9	10	10	10	..

RECAPITULATION BY CONTINENTS

North America	2,385	2,050	2,059	2,193	2,316	1,534
South America	94	52	70	87	71	84
Europe	438	438	510	395	486	..
Africa	36	38	34	33	22	32
Australasia	10	9	10	10	10	..
Total	2,963	2,587	2,683	2,718	2,905	1,989

THIRTY YEARS OF CORN PRICES AT CHICAGO, NO 2 CASH

[IN CENTS PER BUSHEL]

Year	Jan	May	July	Sept	Dec
1902	56@65	59@ 65	72@90*a*	57@63	44@57
1901	36@38	43@ 59	43@58	54@60	62@66
1900	31@32	36@ 41	38@45	39@43	35@41
1899	35@38	33@ 34	31@35	31@35	30@32
1898	26@28	32@ 37	32@36	29@31	33@38
1897	21@23	23@ 26	24@29	27@32	25@27
1896	25@28	27@ 30	24@28	19@22	22@24
1895	40@46	46@ 55	41@47	31@36	24@27
1894	34@36	36@ 39	40@46	48@58	44@48
1893	40@45	39@ 45	35@42	37@43	34@37
1892	37@39	40@100*a*	47@52	43@49	39@43
1891	47@50	55@ 70	57@66	48@68	39@59
1890	28@30	32@ 35	33@47	44@50	47@53
1889	33@36	33@ 36	34@37	30@34	29@35
1888	47@50	54@ 60	45@51	40@46	33@36
1887	35@38	37@ 39	34@38	40@44	46@52
1886	36@37	34@ 70	34@45	36@41	35@38
1885	34@40	44@ 49	45@48	40@45	36@43
1884	51@58	52@ 57	49@57	51@87	34@40
1883	49@61	52@ 57	47@53	47@53	54@63
1882	60@62	68@ 77	74@83	57@75	48@60
1881	36@38	41@ 45	45@51	60@74	58@64
1880	36@41	36@ 38	33@38	39@41	35@42
1879	29@31	33@ 36	34@37	32@39	39@43
1878	38@44	34@ 41	35@41	34@38	29@32
1877	41@44	43@ 58	46@51	41@46	41@46
1876	40@45	44@ 49	42@48	43@48	43@47
1875	64@70	60@ 76	67@77	54@62	45@54
1874	49@61	55@ 66	58@80	66@86	71@85
1873	30@31	37@ 43	32@34	32@44	44@54

a Abnormal price, due to temporary manipulation of market.

EXPORTS CORN FROM SURPLUS COUNTRIES—BUSHELS

Calendar Years	United States *a*	Argentina	Russia	Canada *a*	Egypt	Bulgaria	Roumania
1901	176,588,000	43,784,474	19,162,000	*d*438,246	50,090	9,882,851	*c*
1900	209,348,000	28,079,300	*b*12,287,448	2,142	61,286	1,595,420	17,089,215
1899	174,089,000	43,945,790	*b*18,447,939	40,932	106,036	6,187,681	23,442,889
1898	208,745,000	28,231,140	29,868,421	2,389	39,634	5,223,847	44,063,029
1897	176,916,000	14,760,800	13,645,743	53,913	326,185	3,071,110	30,776,447
1896	99,993,000	61,828,450	8,341,319	9,765	43,062	4,248,449	17,475,964
1895	27,691,000	30,287,000	19,464,857	120	1,507,324	1,732,857	11,815,571
1894	65,325,000	2,157,000	17,452,214	734	867,246	7,635,500	24,801,062
1893	46,037,000	3,300,157	10,245,857	2,790	49,873	11,453,607	43,289,414
1892	75,452,000	17,487,647	13,872,857	394	1,199,184	2,784,714	23,488,580
1891	30,768,000	2,584,666	18,134,357	180	3,983,747	1,543,653	25,032,480
1890	101,973,000	27,736,500	13,248,000	....	221,848	5,266,600	29,267,000

a Year ending June 30. Figures for Canada relate only to Canadian grown. Exports of corn from United States year ended June 30, 1902, were only 26,324,000 bushels, owing to short crop and high prices.

b Exclusive of exports over the Asiatic frontier.

c Figures not available. *d* Eleven months to May 31.

TEN YEARS' MOVEMENT OF UNITED STATES CORN CROP

[In millions of bushels. Crop year July 1 to following June 30]

	1902–3	1901–2	1900–1	1899–0
Total crop..........	2,556	1,419	2,188	2,666
On farms March 1...	....	429	825	862
Farm stocks % of crop	....	30.2	37.7	39.0
Visible supply July 1	6	14	11	14
12 mos exports......	*a*13	27	178	209
Chicago price Nov..	52@58	57@64	35@50	31@33
Chicago price May..	*b*46@48	59@65	50@55	36@41

a Six months only, July 1, 1902, to January 1, 1903.
b January, 1903.

VISIBLE SUPPLY OF CORN IN UNITED STATES AND CANADA

[In round millions of bushels, first week of month named. This represents the amount in public warehouses in the large cities east of the Rocky mountains, and afloat on canals and lakes.]

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
1902	12	12	10	9	6	4	6	7	3	3	3	4
1901	11	15	20	22	19	16	14	13	13	14	13	11
1900	13	15	20	23	18	12	11	12	5	8	8	9
1899	21	28	33	33	22	13	14	10	7	12	13	12
1898	38	40	41	43	27	21	23	18	17	21	24	20
1897	20	23	26	25	17	14	16	17	31	37	45	40
1896	6	12	13	17	11	10	9	12	14	14	19	17
1895	11	13	13	13	9	11	9	5	5	5	5	6
1894	10	15	19	17	10	8	5	4	3	4	3	5
1893	11	14	16	15	10	8	8	7	6	9	8	7
1892	7	7	10	12	6	4	8	7	8	11	13	11
1891	3	3	3	3	3	6	4	4	7	8	3	2
1890	9	12	14	21	13	14	14	12	8	9	7	2
1889	10	13	16	17	12	12	9	7	12	12	8	6
1888	6	7	9	9	8	9	11	8	8	10	11	7
1887	14	16	16	19	19	13	10	8	6	7	8	5
1886	8	7	11	16	12	8	9	9	12	13	13	11
1885	4	5	6	9	8	5	5	4	5	5	5	4
1884	10	13	14	17	12	8	7	4	4	7	5	5
1883	9	11	14	18	17	14	13	11	11	14	10	9
1882	17	18	14	10	8	10	7	6	6	7	4	[illegible]
1881	16	17	16	14	13	10	15	16	23	27	26	19

AMOUNT OF DIGESTIBLE NUTRIENTS IN THE CORN PLANT[a]

The average percentage of digestible nutrients supplied by the grain, the mill products and the different parts of the corn plant:

	Protein %	Carbohydrates %	Fat %
Grain, mill and by products			
Corn—all determinations	7.9	66.7	4.3
Dent corn	7.8	66.7	4.3
Flint corn	8.0	66.2	4.3
Sweet corn	8.8	63.7	7.0
Corn and cob meal	4.4	60.0	2.9
Cob meal	0.4	52.5	0.3
Corn bran	7.4	59.8	4.6
Gluten meal	25.8	43.4	11.0
Germ meal	9.0	61.2	6.2
Starch refuse	11.4	58.4	6.5
Grano gluten	26.7	38.8	12.4
Hominy chops	7.5	55.2	6.8
Glucose meal	30.3	35.3	14.5
Sugar meal	18.7	51.7	8.7
Starch feed, wet	5.5	21.7	2.3
Silage, fodder, etc			
Corn silage	0.9	11.3	0.7
Corn fodder, green [b]	1.0	11.6	0.4
Corn fodder, field cured	2.5	34.6	1.2
Corn stover, field cured [c]	1.7	32.4	0.7

a From Henry's Feeds and Feeding.
b The entire plant.
c What is left after the ear is removed.

UNITED STATES CORN ACREAGE AND CROP

	Acres	Bushels	Average yield per acre	Exports, year ended June 30
1902	94,488,000	2,556,311,000	27.1	26,637,000
1901	91,206,000	1,418,849,000	15.5	177,818,000
1900	85,294,000	2,188,000,000	25.7	29,348,000
1890 [a]	72,088,000	2,122,328,000	29.4	101,974,000
1880	62,369,000	1,754,592,000	28.1	93,648,000
1870	*b*	760,945,000	*b*	10,677,000
1865	18,990,000	704,428,000	37.0	14,466,000
1860	*b*	838,793,000	*b*	4,249,000
1850	*b*	592,071,000	*b*	7,633,000
1840	*b*	377,532,000	*b*	*b*

a In census years 1890, 1880, etc. figures relate to crops grown preceding year.
b Figures not available.

CORN CROP OF THE UNITED STATES

Leading Corn States	United States Corn Crop of 1902			Federal Census Figures		
	Acres	Yield per acre, bu	Bushels	1900 Bushels	1890 Bushels	1860 Bushels
New York...	670,000	24.0	16,080,000	20,024,850	15,109,969	20,061,049
Pennsylvania	1,477,000	30.0	44,310,000	51,869,780	42,318,279	28,196,821
Texas	5,351,000	13.5	72,239,000	109,970,350	69,112,150	16,500,702
Arkansas	2,485,000	21.3	52,931,000	44,144,098	33,982,318	17,823,588
Tennessee ...	3,425,000	22.8	78,090,000	67,307,390	63,635,350	52,089,926
West Va.	776,000	25.2	19,555,000	16,610,000	13,730,506	....
Kentucky....	3,415,000	26.0	88,790,000	73,974,220	78,434,847	64,043,633
Ohio	3,950,000	36.5	144,175,000	152,055,390	113,892,318	73,543,190
Michigan	1,577,000	30.0	47,310,000	44,584,130	28,785,579	12,444,676
Indiana......	4,550,000	37.5	170,625,000	178,967,070	108,843,094	71,588,919
Illinois	9,650,000	38.0	366,700,000	398,149,140	289,697,256	115,174,777
Wisconsin ...	1,725,000	29.1	50,198,000	53,309,810	34,024,216	7,517,300
Minnesota ...	1,708,000	27.3	46,628,000	47,256,920	24,696,446	2,941,952
Iowa	9,275,000	35.5	329,263,000	383,453,190	313,130,782	42,410,686
Missouri.....	6,925,000	36.8	254,840,000	208,844,870	196,999,016	72,892,157
Kansas	7,735,000	28.5	220,448,000	229,937,430	259,574,568	6,150,727
Nebraska	7,411,000	34.5	255,680,000	210,974,740	215,895,996	1,482,080
North Dakota	65,000	22.8	1,482,000	1,284,870	178,729	20,269
South Dakota	1,505,000	13.0	19,565,000	32,402,540	13,152,008	....
California ...	56,000	28.0	1,568,000	1,477,093	2,381,270	510,708
Oregon	20,000	23.0	460,000	359,523	238,203	76,122
Washington .	10,000	25.0	250,000	218,706	156,413	4,712
Oklahoma ...	1,500,000	29.2	43,800,000	38,239,880	234,315	....
Other	19,277,000	12.0	231,324,000	301,024,289	204,123,919	233,318,748
Total.......	94,488,000	27.1	2,556,311,000	2,666,440,279	2 122,327,547	838,792,742

Legal Weights of Grain--Pounds per Bushel

[Carefully compiled from official sources]

	Corn Shelled	Corn Ear	Oats	Rye	Barley	Wheat
Maine	56	—	32	—	—	—
New Hampshire	56	—	32	56	—	—
Vermont	56	—	32	56	48	—
Massachusetts	56	—	32	56	48	60
Rhode Island	56	70	32	56	48	60
Connecticut	56	—	32	56	48	60
New York	56	—	32	56	48	—
New Jersey	56	—	30	56	48	60
Pennsylvania	56	—	32	56	47	60
Delaware	56	70	32	56	48	60
Maryland	*a*	—	26	—	—	—
Virginia	56	70	30	56	48	—
North Carolina	56	—	32	56	48	—
South Carolina	56	70	32	56	47	60
Georgia	56	70	32	56	47	—
Florida	56	70	32	56	48	60
Alabama	56	70	32	56	47	—
Mississippi	56	72	32	56	48	60
Louisiana	56	72	32	56	48	—
Texas	56	70	32	56	48	—
Arkansas	56	70	32	56	48	—
Tennessee	56	—	32	56	48	60
West Virginia	56	—	32	56	48	60
Kentucky	56	72	32	56	47	—
Ohio	56	68	32	56	48	—
Michigan	56	70	32	56	48	—
Indiana	56	68	32	56	48	—
Illinois	56	70	32	56	48	60
Wisconsin	56	—	32	56	48	—
Minnesota	56	70	32	56	48	—
Iowa	56	70	32	56	48	—
Missouri	56	70	32	56	48	60
Kansas	56	70	32	56	48	—
Nebraska	56	70	32	56	48	—
Oklahoma	56	70	32	56	48	—
California *b*	52	—	32	54	50	—
Washington	—	—	—	56	48	—
Oregon	56	—	32	56	46	—
Colorado	56	70	32	56	48	60
North Dakota	56	70	32	56	48	—
South Dakota	56	70	32	56	48	—
Montana	56	70	32	56	48	60

a 335 pounds per barrel. Oats 32 pounds, according to Baltimore Chamber of Commerce; shelled corn 56, wheat 60, rye 56, barley 48.

b In Arizona, Idaho, Nevada, New Mexico, Utah and Wyoming, no state or territorial laws, cereals being sold almost exclusively by weight. This true to some extent in California, Oregon and Washington.

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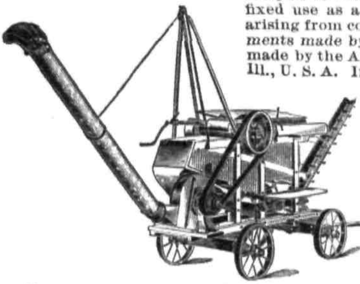
"APPLETON QUALITY"

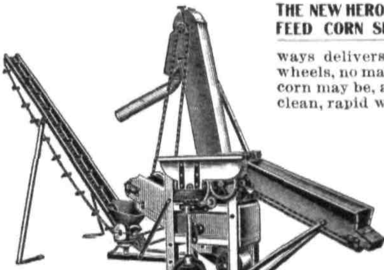


is a pair of words which has come to have a fixed use as a standard of measurement, arising from comparing agricultural implements made by other concerns with those made by the Appleton Mfg. Co., of Batavia, Ill., U. S. A. In the long list of goods made by this concern there are none which better show the pre-eminent worth of Appleton Quality than the three machines shown on this page.

—o—

THE APPLETON CORN HUSKER is positively guaranteed, under the same conditions of operation, to do more and better work, and to require less power for successful operation, than any other machine of like character and corresponding size on the market, and it is sold at a price which fits the purse.

—o—

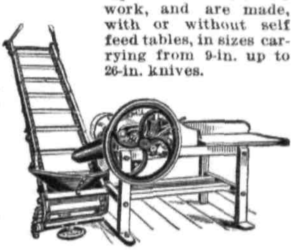


THE NEW HERO FORCE FEED CORN SHELLER never becomes clogged, fouled or disabled, but always delivers the corn to the picker wheels, no matter in what condition the corn may be, and is unexcelled for good, clean, rapid work.

—o—

THE NEW HERO ENSILAGE AND FODDER CUTTERS

are justly celebrated for simplicity of construction, strength and durability, ease of operation, rapid and effective work, and are made, with or without self feed tables, in sizes carrying from 9-in. up to 26-in. knives.



Our space admits of merely a mention of the extensive line of feed grinders, hand and power corn shellers, wood saws, tread powers, windmills, etc., made by this concern and everywhere recognized as standard articles of their kind, but a postal card addressed to the company, mentioning THE BOOK OF CORN, will bring you a large illustrated catalog, fully describing all the goods, and without cost to you.

APPLETON MFG. CO.

55 Fargo St., Batavia, Ill., U. S. A.

RECORD CROPS GROWN WITH THE MAPES MANURES

"American Agriculturist" Prize Potato-Growing Contest. Yields from one measured acre. All records surpassed by the Mape. Potato Manure. "New secrets in Nature's Laboratory." The two largest crops of Potatoes ever grown with fertilizers or farm manure grown with the Mapes Potato Manure alone.

The following were the Largest Crops of potatoes grown in each state—and *all* these crops were grown *exclusively* with the Mapes Potato Manure:

Maine, Aroostook County	745 bushels
The largest crop ever grown in Maine. Second largest ever grown with fertilizers.	
Colorado	847 bushels
"The largest crop ever grown with fertilizers or manure."	
Massachusetts	355 bushels
Connecticut	390 bushels
The largest crops grown in Massachusetts and Connecticut in season 1889 (280 and 340 bushels) were also grown with the Mapes Potato Manure.	
Minnesota	325 bushels
Idaho	479 bushels

The largest crops in each state grown with other fertilizers and farm manures, season 1890, were as follows:—595, 522, 506, 351, 325, 319 and 307 bushels per acre.

SUMMING UP THE POTATO CONTESTS

In *seventeen* states in which the largest crop was grown with fertilizers, 1889 and 1890, *ten* crops were grown exclusively with the Mapes Potato Manure; 847, 745, 669, 532, 479, 460, 428, 393 and 324 bushels per acre.

Average yield per acre, 522 bushels.

In the *seven* states in which the largest crop was grown with fertilizers other than the Mapes, the yields were as follows: 506, 454, 444, 401, 325, 319 and 307 bushels per acre.

Average yield per acre, 394 bushels.

The Great Corn Contest of the American Agriculturist

Crops 213, 119 and 95 Bushels Each; Grown on One Measured Acre Exclusively with the Mapes Corn Manure.

Of this great crop, 213 bushels shelled corn, grown in Yates County, N. Y., with the Mapes Corn Manure (800 pounds per acre) exclusively, the American Agriculturist says: "If we allow only $15 as the value of the tops for fodder, and make no account of bottom stalks, the cost comes within twenty cents a bushel (shelled corn)."

The largest crop grown with fertilizers other than the Mapes (45 crops in all) was 84 bushels (chemically dried, 60 bushels).

Some Large Crops Grown with the Mapes Corn Manure and Reported in the Agricultural Press.

Season of 1888—1040 bushels of corn—ears—on less than 4 1-2 acres, equal to 233 1-2 bushels, or 116 3-4 bushels shelled corn per acre, grown on farm of Rural New Yorker, with the Mapes Corn Manure.

Ninety bushels—shelled—with 500 pounds per acre. 150 bushels—shelled—with 600 pounds per acre. Value of the grain alone over five times as much as the cost of the fertilizer.—American Agriculturist.

Eight hundred and fifty-six bushels—ears—on four acres. 159.37 bushels on one acre. 125.37 bushels on one acre. Nothing used but the Mapes.—Rural New Yorker.

On two acres 600 pounds of Mapes alone, broadcast, 198 bushels shelled corn. On three acres, same fertilizers, same quantity. Four hundred and eighty-nine bushels—ears—grown by Dr. Henry Stewart.—New England Homestead.

One hundred and eighty bushels of ears per acre; shelled, 98.45 bushels. 2058 bushels—ears—on sixteen acres. Only Mapes, 800 pounds per acre, used.—Connecticut Farmer.

The Mapes Formula & Peruvian Guano Co.,

143 Liberty St., New York.

How to Make Poor Farms

Good Dividend Payers

In Rural New-Yorker, November 22d, 1899, Mr. H. W. Collingwood, in his account of bringing up a poor farm, by Mr. Newton Osborn, Newington, Ct., says: "Mr. Osborn thought at that time that the ability to feed a soil was measured by the supply of animal manure. He first proved that a high-grade complete fertilizer will fully take the place of manure. That point settled, he had the key to the situation, and applied it. Instead of being a soil loafer, that field began at once to pay a profit. It was so poor that it had never paid even the interest on the taxes. In six years it was paying dividends of 5 per cent. on a valuation of over $4000. Where can one find, outside of a gold mine, an instance where poor soil has gained proportionately greater earning capacity in six years?" "Corn the 'key' crop."

HEADS THE LIST—150 Fertilizers—FOR CHEAPNESS TO THE FARMER. The Mapes Seeding-Down Manure

For seeding down Spring and Fall, also for Apple, Peach and all Fruit Orchards, Grapes, Small Fruits, etc. A land strengthener.

	Ammonia.	*Phos. Acid.*	*Potash.*
Guaranteed analysis, per cent . . .	3.00	18.00	10.00
Average of analysis by the Conn. Agricultural Station for 12 YEARS	3.22	17.39	11.50

Heads the list in the Official Report 1901 of the Connecticut Agricultural Experiment Station as showing the least difference between cost to the farmer and the calculated market value of plant food contained.

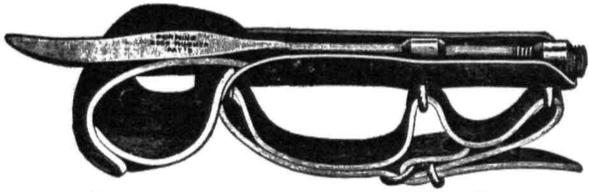
See Official Report, 1901, for Official Analyses (150 different brands) October 31, 1901

Send for descriptive pamphlets. Orange groves 300 acres, Strawberries 230 acres, Asparagus 165 acres, Potatoes 100 acres, etc.

The Mapes Formula & Peruvian Guano Co.,

143 Liberty St., New York.

Complete Line Hand Corn Huskers



No B. Nickel Plated Steel. Best Calf Strap. Buckle Adjustment

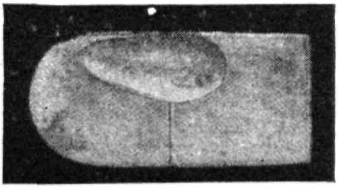
HUSKING PINS

These round steel pins are known the world over. Have been on the market since 1888 and thousands of huskers give testimonials of their value.

HOOK HUSKERS

Hooks have come into use during the last five years. Some farmers say they can husk twice as much with a Hook. This comes on the thumb and leaves fingers free to grasp the ear. The cut represents a Hook combined with a wrist supporter to strengthen the wrist.

HUSKING MITTENS



Have been in general use for years, but not considered so much a necessity as now—made in all weights and sizes of Canton Flannel, Duck and Ticking.

We manufacture a complete line of Husking Goods for hand use:

GLOVES and MITTENS, WRIST SUPPORTERS, PINS, COTS, PROTECTIONS for thumb, finger or whole hand—above comprises some 50 Styles and Lot Nos.

We manufacture also full line—some 100 Styles and Lot Nos—of COTTON GLOVES and MITTENS used in general work, as well as corn husking.

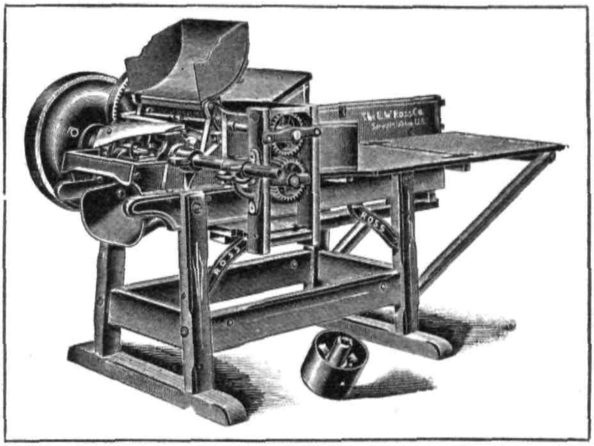
All our goods are sold only through the Jobbing Trade, but while we do not visit or sell retail trade we should be pleased to advise any consumer or retailer where he can find our line.

THE BOSS MANUFACTURING CO, Kewanee, Ill

To Properly Prepare Cornstalks for Feed—Use

ROSS FEED SAVING IMPLEMENTS

Namely: Ensilage Cutters, Fodder Cutters and Shredders, and Corn Huskers



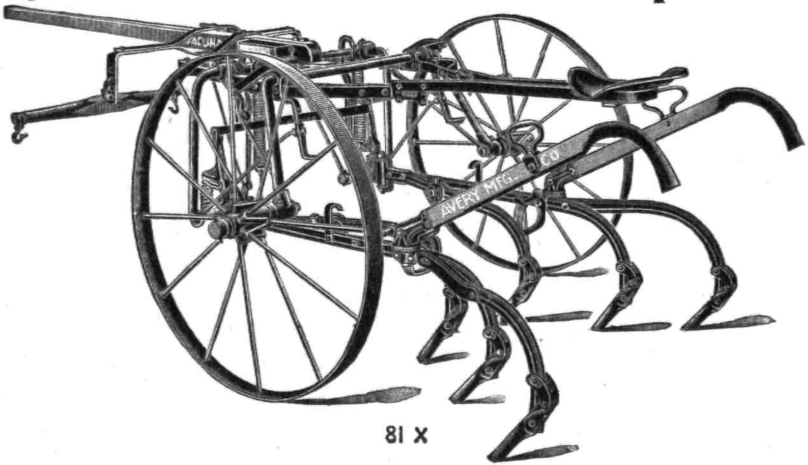
Furnished with Blower or Carrier as desired
With or Without Traveling Feed Table

The Ross Machines are known the world over for their Strength, Capacity, etc.

Write to us for Catalog and Feed Saving Literature and send Ten Cents for Prof Woll's Book on Silage

Address **THE E. W. ROSS CO**, Springfield, Ohio

They Stand Alone in Popularity



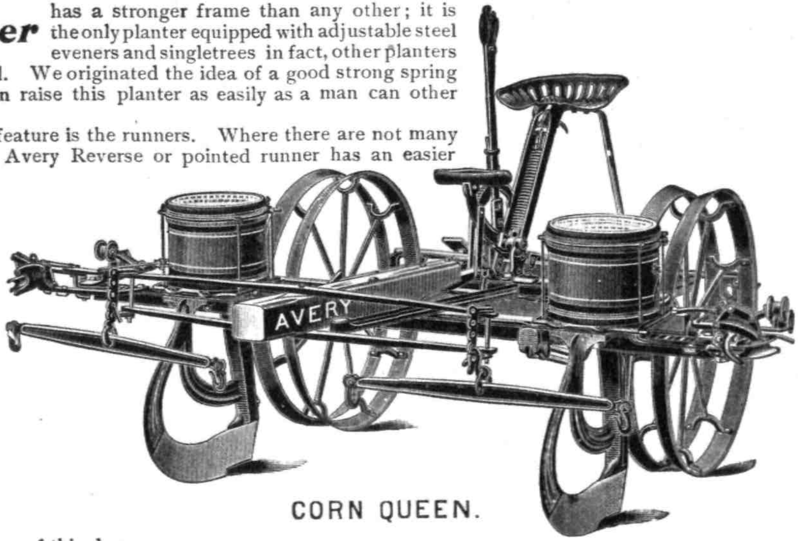
81 X

The Vacuna Cultivator is very much different from any other and stands very nearly alone as a popular combined riding and walking cultivator, capable of doing the finest possible work. Its most attractive features are, its substantial wheels with wide tires, being built right down to the work and handling with great ease. The shovels are of an especially good shape and always go in well and it does practically the same work, as far as plowing is concerned, as the celebrated Avery Mystic.

The Planter has a stronger frame than any other; it is the only planter equipped with adjustable steel eveners and singletrees in fact, other planters have no eveners at all. We originated the idea of a good strong spring lift, so that a boy can raise this planter as easily as a man can other planters.

Another special feature is the runners. Where there are not many rocks or stumps the Avery Reverse or pointed runner has an easier draft than a sled runner and will cover more corn than any sled runner.

No planter has a drop that has as few pieces or one that has as little chance of getting out of order. It has no triggers, cogs or springs to bother. Other makes have found it necessary to change their drops but no user of Avery planters has ever found fault with the evenness or correctness of this drop.



CORN QUEEN.

Avery Manufacturing Company, Peoria, Ill.